ALBERTA WATER COUNCIL

MARCH 2013

Recommendations to Improve Non-Point Source Pollution Management in Alberta

About the Water Council

The Alberta Water Council is a multi-stakeholder partnership with members from governments, industry and non-government organizations. All members have a stake in water. The Alberta Water Council is one of three types of partnerships established under the *Water for Life* strategy: the others are Watershed Planning and Advisory Councils and Watershed Stewardship Groups.

The Alberta Water Council regularly reviews implementation progress of the *Water for Life* strategy and champions the achievement of the strategy's goals. The Council also advises the Government of Alberta, stakeholders and the public on effective water management practices, solutions to water issues and priorities for water research. The Council may advise on government policy and legislation. However, the Government of Alberta remains accountable for the implementation of the *Water for Life* strategy and continues to administer water and watershed management activities throughout the province.

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Executive Summary

The Alberta Water Council established the Non-Point Source Pollution project team to "*Provide recommendations on how to better manage the total non-point source contaminant loading in our watersheds to achieve Water for Life goals.*" Two consultant reports were commissioned, one to help determine the state of knowledge of NPSP in Alberta and the other to review current policies, practices and regulations in Alberta and other jurisdictions.[1] The findings from these reports were considered along with the team's research findings to develop this report and recommendations.

This report is the first of its kind to use a multi-stakeholder, watershed-based approach to develop provincial policy recommendations for addressing non-point source pollution (NPSP). The cumulative effects of NPSP, in conjunction with point source pollution and the contribution of natural processes to water quality within a watershed, are not well understood. Historically, each sector has attempted to tackle NPSP concerns independently rather than taking a more integrated, holistic approach at the watershed level. With Alberta moving towards cumulative effects management, regional planning through the Land Use Framework and watershed management planning through the *Water for Life* Strategy, developing a process for integrating NPSP management into our land-use and watershed management systems is timely.

The Council's recommendations focus on building the solid scientific knowledge foundation required to manage NPSP. At present, the extent and contribution of NPSP in any given water body is relatively unknown, which makes it difficult to develop effective management strategies. To manage NPSP, we need knowledge and tools to determine how much there is (quantification), where it is coming from (research), if it is a problem (evaluation) and what we can do about it (mitigation).

As Alberta's population grows and land use intensifies, the extent and risk of NPSP will increase, which may lead to water quality degradation. A proactive approach to managing NPSP is more cost-effective and timely than remediation. Incorporating focused NPSP management into Alberta's land-use and watershed management systems will help the province move towards

1 The two consultant reports are available on the Council's website at www.awchome.ca/Projects/NPSPollution/tabid/134/Default.aspx

a more proactive approach. With this in mind, to improve NPSP management in Alberta, the Council makes the following recommendations:

Planning Approach:

Recommendation 1: Government of Alberta, with Alberta Environment and Sustainable Resource Development, within one year of the approval and release of this report, identify an internal Non-point Source Pollution lead that will coordinate and facilitate the development of a multi-stakeholder process to set the direction on how to better manage NPSP.

Recommendation 2: GoA, with ESRD as lead, through the multi-stakeholder process, coordinates and promotes the development and implementation of a provincial strategic approach. This will set provincial level outcomes and priority research needs for NPSP management. The provincial strategic approach will also outline alignment with existing policy frameworks and the development of regional plans and associated management frameworks. This approach to NPSP will be completed within two years of the approval and release of this report.

Implementation Approach:

Recommendation 3: GoA, with ESRD as lead, within two years of the approval and release of this report, will coordinate a Multi-Sector Implementation Advisory Partnership that will recommend cost effective and practical solutions to address NPSP and support implementation.

Research Approach:

Recommendation 4: GoA, with ESRD as lead, within two years of the approval and release of this report, create and coordinate an NPSP Cumulative Effects Research Partnership to address the gaps in scientific knowledge of all aspects of NPSP in Alberta.

Recommendation 5: GoA, with ESRD as lead, in collaboration with the NPSP Cumulative Effects Research Partnership, develop an NPSP research strategy within two years of the approval and release of this report, which will lead to better understanding and improved management of NPSP.

1.0 Introduction

1.1 The Issue

Physical, chemical and biological characteristics and processes in a watershed affect water quality. Moreover, characteristics observed in a watershed are a function of ecosystem processes in combination with human activities, and are not static. Water bodies and their watersheds are in constant flux and this is reflected in changing water quality or aquatic communities over time. For example, when a large fire occurs in a watershed, the physical, chemical and biological characteristics of the watershed are altered and this is often reflected in the water draining this area. When changes are part of a natural disturbance regime these changes are not considered pollution. However, human-caused changes in the physical characteristics or processes within the watershed that lead to degradation of water bodies are considered pollution. Given the difficulty of tracing back to a single point of origin or discharge, this can more specifically be called non-point source pollution (NPSP).

With the recognition that: 1) human activities and alteration of landscapes can affect water quality and aquatic health; 2) good water quality is important for human health and drinking water, irrigation, livestock, business, recreation and the health of aquatic ecosystems; and 3) pressures on Alberta's landscape continue to increase, the need to quantify the extent or 'state of' NPSP is apparent.

There is some urgency around this issue as NPSP problems are emerging more frequently. These problems include the perception that headwater areas are being degraded due to increasing levels of off-highway vehicle activity, poor water quality in some tributaries has required specific remediation plans, water quality objectives are being exceeded in some of our mainstem rivers; and popular lakes are being closed to contact-recreational use due to water quality issues. To date, many issues have been dealt with in a reactionary manner, primarily through public inquiries. Water quality degradation can lead or has led to increased economic costs including loss of tourism dollars due to beach closures, increased water treatment requirements, and ecological and social costs which are difficult to quantify.

Thus for cost-effective management of NPSP in the long term, the province needs to take a proactive approach regarding NPSP issues to achieve *Water for Life* goals. To manage NPSP, we need knowledge and tools to determine how much there is (quantification), where it is coming from (research), if it is a problem (evaluation) and what we can do about it (mitigation). The development and implementation of the right tools to manage NPSP can enable land-use decision makers to make meaningful and informed decisions to protect water bodies from NPSP, and more proactive solutions may be needed.

1.2 The Project

The Alberta Water Council (AWC) is a multi-stakeholder partnership with members from governments, industry and non-government organizations, all with a vested interest in water. The Council's report *Recommended Projects to Advance the Goal of Healthy Aquatic Ecosystems (March 2009)* recommended that the AWC advance understanding and management of NPSP by 1) conducting a provincial assessment of NPSP knowledge; 2) reviewing public policies and regulations in Alberta and other jurisdictions to find innovative tools to manage NPSP; and 3) suggesting next steps for the improvement of NPSP management in Alberta.

To undertake this work, the AWC struck the NPSP Project Team (see Appendix A for a list of members) whose goal was to *"Provide recommendations on how to better manage the total non-point source contaminant loading in our watersheds to achieve Water for Life goals."* To best utilize resources, the primary focus was on surface water. Recommendations and timelines appear in Appendix B. The specific project objectives are noted below, along with the section of this report in which each objective is addressed:

- Develop a working definition of the term non-point source pollution (*Section 2.0*);
- Assess and provide an understanding of the current "state of" knowledge on NPSP and its management in Alberta (*Section 3.0*);
- Examine the policy, practices and regulatory tools and their implementation both in Alberta and in other jurisdictions to find innovative tools that have been effectively employed to manage NPSP (*Section 4.0*);
- With the knowledge gained, analyze gaps and opportunities that will advance efforts in managing the impacts of NPSP and where appropriate, reducing it (*Section 5.0*); and
- Produce a final report summarizing the above and providing directional advice on how to better manage NPSP in Alberta.

2.0 Definition

The definition of NPSP that was prepared and agreed to by the Council is:

> Non-point source pollution is contamination that enters a water body from diffuse points of discharge and has no single point of origin.

The following supporting characteristics were also developed to supplement the NPSP definition:

- NPSP origins and diffuse points of discharge are not easily identifiable and can be sporadic;
- NPSP is difficult to prevent, measure, control, quantify and manage;
- NPSP is associated with particular land uses, as opposed to individual points of origin or discharge;
- NPSP can originate from activities related to agriculture, forestry, urban development, mining, construction, roads and streets, recreation, hydraulic modification (i.e., dams, channels) and hydro-modification;
- NPSP can be transported by rainwater, snowmelt, runoff, air deposition and groundwater; and
- NPSP discharges to surface water are often not regulated or covered by an approval or code of practice.

3.0 The State of NPSP Knowledge and its Management in Alberta

Using the above definition, a report was commissioned to assess the state of NPSP knowledge in Alberta. Charette and Trites (2011) provided an overview of what is known about NPSP for the province and by major basin.[2] A large quantity of information on NPSP was also reviewed in addition to this report, and the findings are summarized briefly in this section.

Although NPSP is known to occur, the extent and risk of NPSP in Alberta is unknown. Streams, tributaries, and lakes are most affected by NPSP due to their relatively low dilutive capacity. Impairment of water quality in these water bodies is of particular concern for fisheries, as small streams and lakes often provide Alberta's primary fish habitat.[2]

Contributions of NPSP vary across watersheds and within locations of a watershed, which makes it important to have a good understanding of NPSP on a watershed-specific basis. Variations in NPSP occur owing to Alberta's natural watershed variability in land surface forms (shape, size, and slope of the earth's surface), soil textures, geology, vegetation, wildlife, hydrology and climate. The transport of NPSP is most common when surface runoff occurs during snowmelt and rainfall. Critical source areas or areas with high connectivity to water are the most likely to contribute NPS pollutants to streams.

NPSP has been documented to occur from many activities in Alberta, including agriculture, forestry, mining, oil and gas, recreation, and urban development. Other local activities also contribute to NPSP; examples include golf courses, chemical treatments of lakes, fertilizer applications, and invasive species movement. The scientific knowledge of NPSP and solutions vary by sector, with some sectors further advanced than others. Some work has been done in Alberta's agriculture, forestry, and municipal sectors although knowledge gaps still exist, particularly on the effectiveness of beneficial/best management practices (BMPs).

The risk of agricultural NPSP is greatest for those watersheds that have the highest proportion of their basins as agricultural land and where agricultural development is intense, namely within the Oldman, Battle, and Red Deer River watersheds. The impacts of forestry clearing activities are well studied in the Athabasca River watershed and the impacts of wildfires are being studied in the Oldman River watershed. Linear disturbance from road construction poses the largest risk of NPSP. In forestry as with the oil and gas and mining sectors, the NPSP risks of linear disturbance from road construction are well studied and mitigation strategies continue to be

2 See CPP Environmental Corp. 2011. *Current state of non-point source pollution: Knowledge, data, and tools*. Report prepared by T. Charette and M. Trites for the Alberta Water Council. 154 pp.

developed. The risk of large urban developments to the mainstem water quality of the Bow and North Saskatchewan rivers is relatively well understood but the potential impacts of small municipalities are not as well studied.

The water quality parameters of concern for NPSP will vary, depending on the disturbance activity. Nutrients, pesticides and pathogens are the main constituents of agricultural NPSP. Sediments and pesticides are the main constituents of forestry NPSP. And sediments, metals, nutrients, salts, hydrocarbons from parking lots and roads, pesticides and pathogens are the main constituents of municipal NPSP. Chloride salt from road salt application and runoff is a good indicator of municipal NPSP.

Less is conclusively known about NPSP within Alberta's oil and gas and recreation sectors than in agriculture and forestry. The impact of coal mining on Alberta's eastern slopes is understood. A fair amount of research has been done on the potential NPSP impacts of active oil sands mining but it may be somewhat inconclusive. The potential NPSP from mining operations, like reclaimed sites and linear disturbance, is not well understood. Sediments, hydrocarbons, metals (including selenium), and nitrogen (from explosives) are parameters of concern. Very little is known about recreational (off highway vehicles, campers, and trail users) use impacts on water quality; from the few studies that exist, it is clear that a lack of recreational oversight or over-use in critical source areas can contribute significant loads of sediments to streams.

Although we can state generalities about NPSP, quantification of NPSP remains a challenge on multiple scales. On the large basin scales, inputs from some important tributaries are not known, and these are often located in the headwater areas. This means that summaries of relative NPSP load or amounts from tributaries often cannot be determined and decrease the ability to identify problem areas. At the large basin, tributary, and lake scale it is often difficult to distinguish the contribution of natural background loads from NPSP contributions, again reducing ability to determine the extent of NPSP. Finally, the use of models to help fill data gaps is not fully developed and although they have potential, they have limitations in applicability across eco-regions or watersheds. One notable limitation is the lack of confidence in links between specific land use and the amount and type of NPSP. For more on this, see Appendix C: *A Scientific Primer on Non-Point Source Pollution: Utilizing Agriculture to Tell the Story of Modeling Challenges for NPSP*.

NPSP has been studied using a sector-by-sector approach and hence, a large data gap exists in trying to understand the cumulative impact of NPSP across sectors within a watershed. This is of particular concern for areas in Alberta's watersheds where disturbances such as logging, ranching, oil and gas, and recreational uses occur concurrently, such as in the headwaters.

4.0 A Review of Policy, Practices and Regulation in Alberta and Selected Jurisdictions

4.1 Jurisdictional Review

A second report was commissioned during phase II of the project to identify gaps and opportunities for reducing NPSP in Alberta and to learn from the experience of other jurisdictions. Sanderson and Griffiths (2012) provided an extensive review of legislated requirements and voluntary BMPs for addressing NPSP in Alberta.[3] They also looked at three other Canadian provinces and select jurisdictions in the U.S. and Europe for five major land uses: agriculture, urban development, forestry, oil and gas, and recreation.

This work revealed that many jurisdictions are beginning to address NPSP, but few have a comprehensive integrated NPSP program and even fewer have significantly reduced NPSP.

Like Alberta, most jurisdictions use a variety of tools and approaches to NPSP management. These include education and awareness; incentives and voluntary practices; low impact development guidelines; monitoring and assessment; total loading or discharge limits; water quality credit trading systems; stormwater management plans; bylaws for pesticide and nutrient application backed by enforcement and penalties for non-compliance; and policies that set goals and desired outcomes. For more about these tools, see a summary of the relevant key findings from Sanderson and Griffiths in Appendix E.

While no jurisdiction has a perfect NPSP management system, Sanderson and Griffiths (2012) identified a number of common components and tools that may be needed to manage NPSP. While several of these components exist to some degree in Alberta (see Table 1), the province does not have a comprehensive NPSP management framework or coordinated approach to NPSP.

3 Sanderson, K. and M. Griffiths (2012). Non-Point Source Pollution: A Review of Policies, Practices and Regulations in Alberta and Other Jurisdictions. Green Planet Communications, Edmonton, AB. 242 pp.

Table 1. The Components Identified by Sanderson and Griffiths (2012) for Effective NPSP Management, and Their Status in Alberta

Component or Tool	Current Status in Alberta
1. A clear lead agency that has partnerships with other regulatory agencies	Several government, industry, partnership, stewardship and academic bodies are doing NPSP work (directly and indirectly). However, it is unclear who is ultimately accountable and what the provincial policy direction is.
2. Monitoring that provides good baseline data	ESRD monitors water quality in mainstem rivers but in doing so is not trying to determine whether sources of contaminants are from NPS or point source pollution (PSP). Some industry, agricultural, academic and stewardship groups carry out additional local monitoring.
3. Careful development of a NPSP management plan	No overarching provincial NPSP management plan currently exists although many sectors are undertaking actions to manage NPSP.
4. Sound regulatory framework, which could include legislation and/or incentives backed up by enforcement and compliance	Several sectors (e.g., agriculture, forestry, urban, mining, oil and gas) are regulated by legislation or required to follow beneficial practices. However, for some sectors, it is unclear how well these are complied with or how effective they are at addressing NPSP.
5. Partnerships with other regulatory agencies	The GoA has developed several mechanisms, such as the *Water for Life* Cross-ministry Steering Committee, to coordinate policy, legislation and regulation.
6. Partnerships with non-regulatory bodies	The GoA, through its *Water for Life* and other partnerships, has a mechanism to receive feedback on NPSP policy development and implementation from non-regulatory bodies.
7. Awareness and education for field staff and those found not in compliance	GoA trains its approvals and compliance staff; municipalities and various non-government organizations (NGOs) have education programs which includes BMPs.

Component or Tool	Current Status in Alberta
8. Adequate funding for staff, training, outreach and demo projects, monitoring, inspections and enforcement	This is difficult to assess as there is no single or direct budget for NPSP; however, there is indirect funding from many sources for many of these activities.
9. Implementation and enforcement including adequate budgets and staff	It is difficult to determine if enforcement is effective or adequately resourced. This could be a future area of study.
10. Ongoing monitoring (tracking of outreach and adaptation of plans) and assessment	An ESRD water quality program monitors Alberta's major rivers and other groups conduct some local water quality monitoring. However, these programs rarely distinguish NPSP from PSP. In addition, without an NPSP plan or targets, it is difficult to assess NPSP risk or management.
11. Watershed approach that can address multiple sources via local partnerships	*Water for Life* promotes a watershed approach. As well, under the strategy, a partnership infrastructure with sector representation has been put in place in every major watershed in the province.
12. Measures to address municipal NPS pollution	The Cities of Edmonton and Calgary, Alberta Urban Municipalities Association, Alberta Association of Municipal Districts & Counties, and other municipal representatives are working on a number of initiatives to address urban stormwater and other water quality issues.

4.2 Sector Work in Progress

Before making recommendations on how to improve NPSP management in Alberta, it is important to understand what sectors are already doing. Using existing initiatives and opportunities as much as possible will help make future NPSP work more effective. Some of this sector work is characterized in the two consultant reports discussed above. The Phase II report in particular provides context for NPSP work being carried out by sectors, including the provincial government. The rest of this section briefly describes some sector activities especially worthy of mention For a more complete description of sector activities, see Appendix D: *The State of NPSP: Data, Knowledge and Tools* and Appendix E: The *Review of Policy, Practices and Regulation in Alberta and Selected Jurisdictions* report.

Agriculture

Over a number of decades, research and monitoring of phosphorus levels in Alberta's streams and soils has demonstrated a measurable link with agricultural activities. Tools like manure management plans and environmental farm plans have been used to try and address this issue. Today, the livestock industry, regulated by the *Agricultural Operations Practices Act*, understands that there is a need to:

- Facilitate improved nutrient and manure management in Alberta's livestock sector,
- Demonstrate increased social responsibility, and
- Facilitate cumulative improvement in surface water quality.

Managing phosphorus is a priority of the Intensive Livestock Working Group (ILWG). The ILWG is a provincial organization of livestock producers who are collaborating to develop a long-term manure management strategy to help minimize the livestock industry's impact on surface water quality. Alberta Agriculture and Rural Development (ARD) and the ILWG have initiated a 20-year Phosphorus Strategy including a pilot project that will achieve the following three outcomes:

- The development of a 'tool' that helps confined feeding operations identify risks and opportunities associated with their existing nutrient management system. The tool will also present mitigation options that can reduce phosphorus loss through runoff.
- Implementation and refinement of the tool in a sub-watershed and evaluation of the livestock producer's acceptance of the tool. The intent is to evaluate the tool in areas of the watershed that are deemed to pose the highest risk to water quality.
- Determine whether water quality improvements (reduced phosphorus) will result from broad-scale implementation of the tool on a sub-watershed scale.

Similarly, Alberta Irrigation Projects Association (AIPA) is involved in water quality studies in collaboration with ARD and other agencies. AIPA is helping to fund and is cooperating in a five-year surface water quality study to determine the concentration of over 150 chemical, physical and biological parameters in water that supplies the Irrigation Districts, moves through the districts, and is being discharged from the districts back into the river systems or closed basins. This will determine the quality of water entering the district that may affect crop production but will also give a good idea of the amount of NPSP added within the district boundaries. District managers are prepared to encourage changes in practices in their districts that disproportionately affect water quality downstream.

AIPA is also funding a groundwater study to examine the impact of feedlots and manure spreading on the nitrate content of groundwater in the Lethbridge Northern Irrigation District. They hope to determine the concentration of nitrates, their origins, and their direction and rate of movement in the groundwater system, with an eye to determining if there is any environmental or domestic drinking water threat.

Forestry

The potential for sediment and erosion to contribute to NPSP via forestry sector activities is addressed through compliance with the regulatory requirements for Forest Management Planning, as well as through Operating Ground Rules and Codes of Practice. Much of the Green Area, which is publicly owned, and parts of the White Area, which is largely privately owned and managed by municipalities, may be part of a Forest Management Unit (FMU) within a watershed. Forest Management Units are administered by the Province. Within the FMU there are several Forest Management Areas, which are managed using Forest Management Agreements (FMAs) and Plans written by forestry companies who operate within the Forest Management Area. The forestry sector has been doing extensive research into the effects of its activities on water quality and NPSP in particular, which may place them farther along than some sectors in understanding risk.

The forestry sector has used watercourse buffers as a major tool to reduce erosion, and today has over a million hectares of water buffers to help mitigate NPSP. Most FMA holders are third party certified (e.g., Sustainable Forest Initiative) with specific requirements for operating in watersheds, including an audit component.

In recent years, operators have begun using wet-areas mapping (which identifies potential wet areas on a landscape) and other geo-spatial tools to plan roads and harvest areas to avoid wet areas or sequence them for operations during frozen conditions. The forest sector is also

collaborating with several research organizations (Lakehead University, Foothills Research Institute, Sustainable Forest Management Network at the University of Alberta, and others) to look at the effects of forest management and practices on watersheds.

Government of Alberta

Water for Life has laid a solid foundation through its goals and key directions to manage NPSP in Alberta's watersheds. The Government of Alberta sees Land-use Framework Regional Planning as an opportunity to further address NPSP through the development of place-based policy direction and environmental management frameworks.

The Bow River Basin Council (BRBC, 2008)[4] has identified water quality objectives for the Bow River, which included targets and limits for phosphorus. In recent years, these objectives have not been consistently met through the Calgary reach of the river. This reach includes major tributaries such as the Highwood and Elbow Rivers, Fish Creek, Nose Creek, Crowfoot Creek and West Arrowwood Creek.

Levels exceeding the objectives have been recorded in the Bow River reach between the Bearspaw and Bassano Dams, particularly during the winter months. To accommodate expected growth and avert pressure and mandatory management actions, Alberta Environment and Sustainable Resource Development (ESRD) initiated a collaborative multi-stakeholder project to develop the Bow River Phosphorus Management Plan (BRPMP) to prevent water quality from deteriorating further.

The BRPMP will identify appropriate strategies and actions to reduce the amount of phosphorus entering the Bow River. Point sources as well as urban and rural non-point sources will be considered. A Surface Water Quality Management Framework is being developed by the GoA for the South Saskatchewan Regional Plan (enabled by the *Alberta Land Stewardship Act*). The triggers identified in this Framework will provide further context for the BRPMP. The BRPMP plan is expected to be ready for implementation in late 2013.

Oil and Gas and Mining

Similar to forestry, the impact from oil and gas development and other resource extraction is likely from roads and other linear corridors, as they can lead to erosion and sedimentation. Given the large footprint of the oil and gas sector in Alberta, it is likely there are impacts from NPSP, but the research to date was not conclusive. Disturbed areas and linear corridors are similar to

4 BRBC. 2008. *Bow Basin Watershed Management Plan, Phase One: Water Quality*, prepared by the Bow Basin Watershed Management Steering Committee, online at www.brbc.ab.ca/index.php/resources/publications/our-publications.

those in forestry which could mean that the oil and gas sector may have similar types of NPSP as the forestry sector. Like forestry, this sector is regulated through the Federal *Fisheries Act*; the Provincial *Environmental Protection and Enhancement Act, Water Act,* and *Public Lands Act*. The industry uses Codes of Practice and beneficial management practices (e.g., for stream crossings) to minimize its NPSP impacts. Road-sharing agreements can be used by this and other sectors to reduce their cumulative linear disturbance. The sector is well regulated in the protection of water courses. In northern Alberta, the reduction of cumulative linear disturbance is being addressed through the Lower Athabasca Regional Plan and its provision for mandatory integrated land management and land disturbance planning.

Recreation

Recreation is a large and diverse sector, which makes it hard to define and even harder to assess its NPSP impact. Recent years have seen a dramatic increase in off-highway vehicle use and random camping, raising concerns that these activities might be significant contributors of NPSP especially in smaller watersheds and hence, need may need closer investigation. Although some studies have been conducted, they were not intended to link into a larger regional or provincial picture. As much of this recreational activity takes place on Crown lands in the Green Area, it makes sense for the Government of Alberta to lead this work. In the meantime, many recreational groups promote a "stewardship" or "responsible use" ethic among their members. A number of such groups are building trails and bridges to limit the area disturbed, and putting up signage and developing other materials to educate trail users of Crown lands. The Government has only limited control of recreational activities on private lands.

Urban/Municipal

Stormwater is a source of NPSP and municipalities must manage stormwater in accordance with provincial and federal requirements such as those developed under the *Canada Wide Strategy for the Management of Municipal Wastewater Effluent*. Urban municipalities have stormwater management plans and programs in place to manage NPSP. Stormwater ponds and constructed wetlands are the most common management practices used to date. More recently, low-impact development (LID) practices are being implemented to more holistically manage NPSP. LID practices trap pollutants at or near the source and slow the movement of overland flow to the river, thus allowing for the natural treatment of contaminants. Riparian protection is also a good tool for managing NPSP. Alberta's *Municipal Government Act* gives municipalities the authority to take Environmental Reserve (ER) setbacks around environmentally significant areas including water bodies, and many municipalities have an ER setback policy, riparian policy and a grading

policy to prevent degradation and loss of riparian lands. Municipalities also use conservation reserves and easements to protect water bodies. Some counties (e.g., Lac La Biche) have developed watershed management plans with scientifically-based ER setbacks that are legally enforceable to better manage road construction, acreage developments and waste water from septic systems.

Both the City of Edmonton and the City of Calgary have Total Loading Management Plans (as required by ESRD) that establish total loading objectives for both point sources and non-point sources. Both cities have developed stormwater management strategies and action plans for managing NPSP from existing and future urban developments. Edmonton is developing a River-for-Life strategy with an objective of achieving net-zero discharge of pollutants to the river from the city's sanitary, combined, and stormwater systems. The City of Calgary is also working with ESRD and other stakeholders on the Bow River Phosphorus Management Plan which uses a water quality framework approach to reduce cumulative effects on the Bow River. Three task teams have been struck to deal with urban and industrial point source, urban non-point source and rural non-point source contributions to phosphorus loading in the Bow River.

Many urban municipalities (both large and small) also use education and awareness programs to engage citizens and encourage them to think about where their stormwater goes and the importance of wetlands, water quality and aquatic health. For example, Calgary's "*Bow is Below*" campaign was a citywide program that helps connect Calgarians to their source waters. The City of Edmonton has a school education program (Treat it Right!) to educate students about the environmental impact of wastewater and stormwater.

Non-government Organizations

A number of multi-stakeholder and non-government organizations are also working to reduce NPSP through education and policy change. The work of these organizations is an important component for NPSP management, but their activities are not strategically aligned. They are also site specific and small scale in comparison to the needs in the province as a whole for consistent management of NPSP. A few examples of initiatives being done in this sector are noted below.

Trout Unlimited Canada (TUC) works to conserve, protect and restore freshwater habitat through public awareness and education, stream clean ups and storm drain pollution prevention education for adults and children (e.g., Yellow Fish Road (YFR)-stormwater pollution prevention program). TUC and the YFR program are partnering with the City of Calgary to incorporate rain barrels and rain gardens in specified pilot communities. TUC also works with landowners

to protect water through beneficial land practices, and has been working to develop stormwater management policy.

Nature Alberta's *Living by Water* program and Alberta Lake Management Society's (ALMS) *Lake Watch* and *Alberta Water Quality Awareness Day* raise awareness about the condition of Alberta lakes and how we can minimize our impact on them. ALMS also collects water quality data and conducts monitoring in partnership with the Province. The Alberta Riparian Habitat Management Associations Cows & Fish program and the Alberta Low Impact Development Partnership are other sources of assessment, education and outreach programs and materials.

As part of their role in implementing *Water for Life*, Watershed Planning and Advisory Councils (WPACs), Watershed Stewardship Groups (WSGs) and other groups independent of WFL are describing land cover and land uses in their basins and have identified several areas of poor or degraded water quality in the province (see summary table of the state of the watershed reports in Appendix F). They then identify potential NPSP sources as they prepare watershed atlases, state of the watershed reports and water quality objectives in a watershed management plan. Some WPACs, such as the North Saskatchewan Watershed Alliance, have developed Integrated Watershed Management Plans, which include goals and actions to reduce NPSP. (For a brief look at potential NPSP issues in Alberta's watersheds, see Appendix E.)

Through partnerships with Ducks Unlimited Canada, Nature Conservancy Canada, the Alberta Conservation Association and other area land trusts and Fish and Game associations, tens of thousands of acres of perennial cover, riparian areas and wetlands have been conserved and restored in Alberta, directly contributing to the interception and reduction of NPSP contamination. Wetland conservation and restoration programs are effective beneficial management practices applied in managing NPSP contamination.

4.3 Alberta's Current Policy Context

In the past, land and water were governed and managed in "silos." With the province moving towards a new era of cumulative effects management and regional planning, combined with *Water for Life's* collaborative and watershed approach, the timing is good to incorporate NPSP into our land use and watershed management systems. Alberta is moving towards a broader provincial approach that looks at the management of NPSP, including air, land, water and biodiversity. NPSP management should integrate with and complement existing initiatives. Thus, Alberta's current policy context was reviewed in relation to water quality management, including the frameworks that exist to address NPSP. The results of this review are briefly described below, recognizing the dynamic nature of policy development and implementation.

Regional planning carried out under the Land-use Framework (LUF) is the overarching planning mechanism for Alberta's natural resources and is enabled by the *Alberta Land Stewardship Act* (ALSA), which prevails over other provincial legislation. At present, the approach is to address land and water planning in an Integrated Resource Management System through the development of management frameworks (including water quality), with a cumulative effects approach. Water quality management frameworks are place-based and, to date, focus on mainstem reaches, occur in priority areas where water quality is at a higher risk and establish limits, thresholds, and triggers that will indicate if land management changes are required to address water quality issues, which could include NPSP. Although the frameworks are supported by ongoing monitoring programs, these programs were not designed to deal with NPSP specifically.

Examples of two such frameworks are the Bow River Phosphorus Management Plan and the Industrial Heartland Water Management Framework. Water management frameworks on mainstems do not account for all NPSP; tributaries and lakes can be disproportionately affected by NPSP due to their low flows or fixed volumes. Specifically, NPSP's role in mainstem rivers where problems have been identified and frameworks established (e.g., Bow River Central) is often masked by point source contribution and/or hard to quantify. There is concern that NPSP will not be addressed at a provincial level through current frameworks under the LUF unless the frameworks are developed and used with a strategic focus on NPSP. Section 5.2.2 of this report provides direction on how NPSP can be quantified through data collection and monitoring specific to NPSP.

WPACs are responsible for developing watershed management plans, but their role in NPSP management is not clear. To date, WPACs have focused primarily on mainstem rivers, and some address NPSP management at a broad basin scale by recommending watershed metrics and water quality objectives for the mainstem reaches. WPACs that are further along in the watershed

planning process outline a move towards better NPSP management by focusing on quantification of loads from tributaries and setting water quality objectives for tributaries and lakes. The expertise, data, and resources available to complete this quantification work may be beyond the capacity of many WPACs. The next step, which involves linking land use practices to NPSP, is in its infancy for WPACs.

In addition to the LUF and WPAC work under the *Water for Life* strategy, NPSP is being addressed to varying degrees through local regional, industrial, and municipal plans. Existing legislation like the *Water Act*, *Environmental Protection and Enhancement Act*, *Agricultural Operation Practices Act* and the Federal *Fisheries Act* provide some direction to these plans, and it is expected that industrial and municipal plans will align with the regional plans. In addition to the legislation, education programs and incentives can also be used to mitigate NPSP. The implementation of actions for NPSP typically include landowners, Water Stewardship Groups, municipalities, developers, and sectors that work on or utilize public lands including forestry, energy, and recreation.

There is opportunity for WPACs, stewardship groups and the province, through the regional water quality management frameworks, to play a larger role in NPSP quantification and management but this cannot happen without support from the scientific research community and strategic direction and leadership at the provincial level. Currently NPSP research, water quality monitoring, spatial data collection and educational initiatives are occurring through a variety of networks. However, this work is not targeted to filling gaps in NPSP knowledge, implementation, and education in a strategic way at a provincial scale. Without a strategic approach to address NPSP with focused monitoring, research, management and implementation at a provincial scale, NPSP management will not be optimized. With continued growth in Alberta it is imperative that the impacts to our water bodies (mainstem rivers, tributaries, and lakes) from NPSP are understood and appropriate land use decisions are made in the interest of all Albertans.

The Council proposes to build on the current state, with the assumption that the GoA will continue with regional planning under the LUF and the *Water for Life* frameworks, and with its support of WPACs and stewardship groups. The recommendations describe the governance structure that will help address NPSP management issues and facilitate integration of effective NPSP management within our existing land use and watershed management systems. This structure is proposed to accompany and to add value to the existing system. Roles and responsibilities are also defined in section 5.

5.0 A New Direction for Non-Point Source Pollution Management in Alberta

A complete picture of the extent of the NPSP problem in Alberta does not exist but NPSP is known to be impairing lakes and small tributaries. Some areas are perceived to have been affected by NPSP and there is a sense of urgency to address NPSP issues. Future growth and development or intensification of land-use activities across the province will increase NPSP, requiring an increase in prevention and mitigation activities.

Therefore, in an effort to be proactive and to address growing future needs for good quality water supplies, it is appropriate to begin to move beyond the status quo of NPSP management in Alberta. Even though not enough is known about NPSP sources, contaminants, amounts or impact on water quality or aquatic health, Alberta can start to put in place an approach to NPSP management that will begin to answer these questions and more.

An improved NPSP management framework needs to fit into the existing policy landscape and should make use of existing management opportunities as much as possible. However, there are a number of gaps in NPSP management, including:

- Lack of a provincial approach or roadmap that outlines what we are trying to achieve and how we will achieve it, including roles and responsibilities;
- Lack of a clear mandate and accountability for NPSP management;
- Lack of scientific knowledge to inform NPSP policy and management; and
- Lack of a coordinated forum for sectors (as the implementers) and all *WFL* partners to provide input into NPSP policy and management as part of an adaptive management approach.

To better manage NPSP and address the barriers to effective management, the following outcomes should be achieved:

- Clearly defined goals, with known roles and responsibilities, identified in a strategic approach through a collaborative process;
- Clear accountability for NPSP management via a clearly identified lead;
- A sound NPSP knowledge base with coordinated research and monitoring that fills priority information gaps, builds knowledge and informs policy; and
- Implementer and sector buy-in via a mechanism for sectors to provide input on NPSP policy and management and to evaluate the feasibility of proposed strategies from the research and monitoring.

These outcomes do not stand alone; all are required and all should be integrated into the existing policy context as described above. This will make NPSP management more transparent, performance-based, and part of ongoing trade-off discussions taking place through the development of regional, watershed and other land-use planning activities. These outcomes are discussed in the following sections; recommendations and timelines are summarized in Appendix B.

5.1 Planning and Implementation Approach

5.1.1 A Collaborative Process for Better NPSP Management

A multi-stakeholder approach to decision making, involving a variety of sectors from planning to implementation, is needed to ensure successful outcomes for improved management of NPSP. Stakeholder involvement enables sectors to better understand each other's needs and barriers to implementation; a multi-stakeholder process also enables sectors to reach agreement on feasible and practical solutions, thus increasing the likelihood of long-term success. It is important to understand the varying capacities of sectors to integrate new ideas and solutions so that realistic timelines and outcomes can be developed. As Alberta moves towards an integrated, multi-sector, multi-stakeholder approach to developing new policy and planning frameworks (i.e., regional planning), it is reasonable that a similar approach be adopted to better manage NPSP.

Based on the literature review, evidence suggests that NPSP programs are managed more successfully when there is a clear leader (Sanderson and Griffiths, 2012). In Alberta, it is unclear who is ultimately accountable for NPSP management. A clearly designated NPSP lead would put NPSP on the radar and would build a vision for advancing NPSP management.

Alberta Environment and Sustainable Resource Development (ESRD), as the provincial water authority and the lead for cumulative effects management, should be the NPSP lead department within GoA and should clearly identify where this portfolio sits within the department by identifying an internal NPSP lead. The provincial lead would take on the role of both coordinator and facilitator in a collaborative, multi-sector, multi-stakeholder process. The lead would also be responsible for identifying and aligning policy, developing goals and objectives, coordinating implementation, and addressing knowledge gaps. In general, the provincial lead would actively promote and be an advocate for improved NPSP management.

The collaborative multi-sector, multi-stakeholder process would include all sectors and stakeholders with an interest in NPSP management issues. This would likely include sectors

and stakeholders that may potentially contribute to NPSP or have an interest in environmental outcomes in relation to NPSP.

> **Recommendation 1:** Government of Alberta, with Alberta Environment and Sustainable Resource Development, within one year of the approval and release of this report, identify an internal Non-point Source Pollution lead that will coordinate and facilitate the development of a multi-stakeholder process to set the direction on how to better manage NPSP.

While the Council recognizes that the lead will have to coordinate the collaborative process, it provides several suggestions for the role of the lead:

- Act as coordinator and facilitator in collaboration with relevant stakeholders to ensure all recommendations from this report are achieved, and actively promote improved NPSP management;
- Work with relevant stakeholders to ensure that NPSP and supporting policies are adaptive and provide provincial-scale consistency in the approach to NPSP management while still being responsive to regional diversity;
- Strengthen relationships, engage and build momentum and commitment from other stakeholders to implement NPSP management;
- Act as facilitator and coordinator to improve information flow between NPSP researchers; relevant GoA departments and others engaged in cumulative effects management, land use planning, and development of water quality management frameworks; and land managers and implementers of NPSP solutions;
- Facilitate engagement at the municipal level to enable municipalities to align and enhance municipal plans with regional plans and, specifically, with NPSP management;
- Encourage leadership, motivation and skill development at the municipal and local level;
- Coordinate and/or support education and awareness of NPSP from a provincial perspective. This could include forums, workshops and websites for shared learning;
- Establish a proactive approach on Aboriginal consultation by hosting a non-point source workshop in Aboriginal communities to discuss water quality monitoring issues and best management practices. The workshop should educate communities on what other sectors are doing to manage NPSP issues;
- Support implementers, including reviewing and assessing the effectiveness of current BMP education and awareness initiatives; and
- Report publicly every two years on the work done by the NPSP lead.

5.1.2 A Collaborative Provincial Strategic Approach

To improve NPSP management in Alberta, a provincial-level strategic approach is needed and should be developed through a collaborative, multi-stakeholder process (as outlined in Recommendation 1). By setting clear provincial goals and outcomes and measuring progress towards them, managers can review and assess the effectiveness of NPSP management in an open and transparent process to determine if there are gaps that new programs, or alterations to existing programs, could fill. A strategic approach would focus on ensuring priority research needs are identified to build the foundation of knowledge that will lead to improved NPSP management.

> **Recommendation 2:** GoA, with ESRD as lead, through the multi-stakeholder process, coordinates and promotes the development and implementation of a provincial strategic approach. This will set provincial level outcomes and priority research needs for NPSP management. The provincial strategic approach will also outline alignment with existing policy frameworks and the development of regional plans and associated management frameworks. This approach to NPSP will be completed within two years of the approval and release of this report.

Although the lead, as part of the multi-stakeholder process, will collectively develop a provincial strategic approach, the following key components for the strategic plan could be considered:

- Clear authority and accountability among the lead and stakeholders to implement the strategic approach. To promote continuity, the key stakeholders in this process can become part of the Multi-Sector Implementation Advisory Partnership which makes recommendations on the effective implementation of proposed management solutions to NPSP;
- Provincial level outcomes;
- An outline of what is needed for the process towards better NPSP management, including a research strategy (see Section 5.2.2 for a detailed description);
- An outline of key interim strategies that can be put in place while the research strategy is being developed and implemented, and coordinated with the other key players to implement (see Section 5.2.2.3 for suggested strategies);
- An outline of the key players with clearly defined roles and responsibilities;
- An outline of an adaptive management approach to integrate NPSP into existing policy, planning and implementation strategies;
- Details on: a) the transfer of information and knowledge between the various stakeholders involved at the policy, planning and implementation levels for the better management of NPSP; and b) the effective integration of NPSP research and strategies into existing land

and water management systems including Regional Plans through the LUF, Management Frameworks through CEMS, and WPAC and stewardship group water management plans;

- An approach for completing a review of existing policy and regulation (and enforcement thereof) to determine the efficacy of the regulatory system on NPSP management (referencing and building on the report: *A Review of Policy, Practices and Regulation in Alberta and Selected Jurisdictions*);
- A plan to ensure implementation programs and approaches are resourced and effective (set clear outcomes and measure progress); and
- Details on how progress will be measured.

Having clearly defined roles and responsibilities outlined within the strategic approach will help ensure that implementation occurs and that authority has been effectively given to the key players to implement the approach. To carry out this approach, three entities are needed and should be defined in the approach; they are: an NPSP lead (as noted above), an NPSP Multi-Sector Implementation Advisory Partnership, and an NPSP Cumulative Effects Research Partnership.

5.1.3 A NPSP Multi-Sector Implementation Advisory Partnership

Since no one agency or sector can manage NPSP alone, the NPSP lead needs to engage sectors that will be implementing on-the-ground solutions as well as those knowledgeable about NPSP barriers. As suggested in Recommendation 1, stakeholders participating in setting the direction for NPSP management can become part of the implementation process, along with other relevant stakeholders and sectors.

The relationship between the sectors as implementers and the existing policy and planning frameworks will also be an important component to effectively address NPSP management. Stronger alignment between planners and implementers is required to achieve the necessary support for on-the-ground management strategies for NPSP. The Council proposes that a Multi-Sector Implementation Advisory Partnership be formed, consisting of representatives of those sectors that would be the implementers. This Partnership would work with the lead to evaluate and recommend cost effective and practical solutions to address NPSP and provide support for policy, planning and implementation. The Partnership would also play a key role in aligning research outcomes with the existing policy and planning frameworks. It might also make suggestions on economic incentives (or disincentives) to encourage implementation.

Recommendation 3: GoA, with ESRD as lead, within two years of the approval and release of this report, will coordinate a Multi-Sector Implementation Advisory Partnership that will recommend cost effective and practical solutions to address NPSP and support implementation.

Although the Multi-Sector Implementation Advisory Partnership will develop its own work plan, the following characteristics and activities of the Partnership should be considered. An Implementation Advisory Partnership should:

- Be a resource and advise land and water planners on NPSP solutions facilitated through the lead;
- Adapt to new knowledge; use an adaptive management approach to receiving new research knowledge and integrate this knowledge with existing plans and strategies;
- Translate applied science to NPSP management strategies to facilitate informed decision making;
- Prioritize and address barriers and challenges to implementation, including policy review and alignment, in collaboration with the lead and research partnership;
- Conduct a cost-benefit analysis of NPSP policies and programs, considering socio-economic and environmental requirements;
- Work with the lead to ensure the flow of adaptive information and support from the sectors to the research, policy and planning levels;
- Conduct a compliance audit for existing policy frameworks. This would include assessing the level of compliance and the adequacy of enforcement in relation to current regulatory standards that relate to NPSP;
- Investigate, coordinate and target incentives and remove disincentives to implementers in consultation with the research group and the lead; and
- Have dynamic membership to adapt to changing needs.

5.2 Research Approach

5.2.1 An NPSP Cumulative Effects Research Partnership

A number of knowledge gaps were identified and need to be addressed before progress on NPSP management can be made; examples of gaps include water quality information for small tributaries and land use export coefficients. There is also an opportunity for NPSP experts to better share technical knowledge and research efforts in a coordinated way, increasing the knowledge transfer to land use planning. Many experts from various sectors (including various GoA departments) are working on NPSP. However, the lack of NPSP outcomes at basin and sub-basin scales means that the cumulative effects of NPSP may not be adequately addressed and NPSP efforts are not targeted nor do they share efficiencies.

To resolve these and other outstanding knowledge gaps, the NPSP lead needs to coordinate an NPSP Cumulative Effects Research Partnership with NPSP experts and relevant NPSP practitioners, including WPACs, academia, research organizations, non-government organizations, and conservation groups.

This Research Partnership should work collaboratively with the lead to develop a research strategy that lists key research priorities (informed by this report) and a path forward to fulfill them. The work of this Partnership should be grounded in rigorous scientific design and execution, be transparent, and lead to the quantification of NPSP. NPSP research and science should build knowledge and inform policy and decision making. This expert Partnership should be informed and supported by implementers and should align existing work and resources.

> **Recommendation 4:** GoA, with ESRD as lead, within two years of the approval and release of this report, create and coordinate an NPSP Cumulative Effects Research Partnership to address the gaps in scientific knowledge of all aspects of NPSP in Alberta.

The NPSP Cumulative Effects Research Partnership will develop its own work plan; however, the following characteristics and activities of the Partnership should be considered. An NPSP Research Partnership should:

- Be created from the coordination of available resources and include non-government entities;
- Be guided by an outcome of '*improved knowledge, fewer information gaps and better informed policy and management*';

- Work collaboratively with the lead to develop a research strategy as part of the provincial NPSP strategic approach (see section 5.2.2 for a detailed description);
- In partnership with the lead, develop a list of key research priorities and needs and determine how this research will be carried out and by whom;
- Inform and be informed by the NPSP lead and the Multi-Sector Implementation Advisory Partnership;
- Work collaboratively with the lead's chosen existing data gathering and monitoring entity (e.g., Alberta's Environmental Monitoring Agency) to share knowledge and implement the research strategy;
- Include primarily researchers and some implementers of ground-based solutions (such as Beneficial Management Practices) for NPSP; these could include WPACs, academia, research organizations, non-government organizations, and conservation groups;
- Be grounded in rigorous scientific design and execution;
- Gain support and buy-in from the Multi-Sector Implementation Advisory Partnership for strategies proposed through the research;
- Working with the lead and Multi-Sector Implementation Advisory Partnership, provide applied science-based advice and potential management strategies informed by the research to water and land planners, managers and landowners (this includes Regional Advisory Committees, WPACs, WSGs, municipal planners, and NGOs);
- Working with the lead, facilitate NPSP technical knowledge (applied science) transfer by enabling the participation of NPSP researchers, educators and those required to implement NPSP management at land and water planning forums and making sure the information needed is at hand;
- Align with current NPSP work; and
- Ensure scientific oversight and organization and integration of activities, and be on-going and resourced appropriately.

5.2.2 A Research Strategy

As part of the proposed NPSP provincial strategic approach, the lead, in partnership with the proposed NPSP Cumulative Effects Research Partnership, should develop a research strategy for effective data collection, monitoring and modeling of NPSP. This work will build a solid foundation of knowledge to enable better management decisions. The strategy aims to link information with those who need it (policy, planners, implementers) and to achieve provincial outcomes in the strategic approach. The NPSP Cumulative Effects Research Partnership should lead the development of this strategy.

It is expected that existing initiatives concerning NPSP management will continue as planned, yet remain adaptive. As the research advances, new information and solutions for better management of NPSP are intended to feed into these existing initiatives to enhance their outcomes.

> **Recommendation 5:** GoA, with ESRD as lead, in collaboration with the NPSP Cumulative Effects Research Partnership, develop an NPSP research strategy within two years of the approval and release of this report, which will lead to better understanding and improved management of NPSP.

The lead, in partnership with the NPSP Cumulative Effects Research Partnership, will have to develop the strategy, but following are some key components that could be considered:

- Identify research priorities for addressing knowledge gaps of NPSP using an applied science approach;
- Identify the most effective methodology for monitoring and data gathering to understand the core issues for NPSP and build a solid knowledge foundation;
- Develop a long-term strategy for data gathering and monitoring, and identify what is needed to better quantify and understand NPSP;
  - The research should use available data and make specific recommendations to start implementing what is already known through an adaptive management approach.
- Outline communication flows between the research partnership and the body(ies) that monitor water quality;
- Identify who should do what by when. This would include data gathering and monitoring for NPSP;
- Develop a staged approach to NPSP research that addresses immediate and long-term goals;
- Use an adaptive management approach to sharing research results and management strategies; and
- Prioritize risk based on sound science.

Several knowledge gaps currently exist in NPSP management. Many initiatives are helping to manage water quality issues as a whole, but unless there is a proper understanding of the contributing factors of NPSP and an ability to quantify those contributions, little can be done to actually improve water quality affected by NPSP. The next sections look in more detail at what is required for the research, including:

- Key considerations and knowledge gaps that should be dealt with for better NPSP management;
- A strategy to ensure effective management of NPSP in the long term; and
- Several potential interim strategies that could be started in conjunction with the long-term strategy to build momentum and move NPSP management efforts forward.

5.2.2.1 What research is needed?

When assessing the extent and impact of NPSP on a specific water body or watershed, some basic questions must be answered:

1. Is NPSP an issue for a given water body or watershed; for example, is it negatively affecting water quality or aquatic ecosystem health in the receiving water body?
2. How much and what type of NPSP is being exported to a receiving water body from its watershed?
3. What land uses, management practices and land cover are contributing to NPSP in the water body?
4. Given the impact on the water body, what mitigation strategies most effectively reduce NPSP impacts?

The answers to each of these questions are complex. They depend on a) the existing body of knowledge around the water bodies and/or watersheds of concern, which varies geographically and depends on scale, and b) the overarching scientific knowledge base of land use linkages to water quality. Some challenges were identified based on research analysis, and subsequent observations in response to the above questions are noted in Table 2, in an Alberta context. The intent is for the research partnership to consider whether or not these observations should be included in their research strategy.

Table 2. Research Questions, Challenges and Observations in Assessing the Extent and Impact of NPSP in Alberta

Question 1: Is NPSP an issue for a given water body or watershed (is it negatively affecting water quality or aquatic ecosystem health in the receiving water body)?

Challenges	Observations
– Can we identify the water quality parameters of concern or that we would expect to be a problem given our knowledge of land-use? – Are background/pre-disturbance conditions known? Do we need to know them? – Are water quality objectives and/ or guidelines relevant for the water bodies in the basin? – Do we have water quality data? – Are these limited to mainstem rivers? Tributaries? Lakes? – Has aquatic ecosystem health been affected by NPSP? – Have health indicators been measured? Where?	– Significant land disturbance has occurred in Alberta in the last 150 years, before monitoring systems were in place, and therefore NPSP is sometimes categorized as 'background levels'. – Water quality and aquatic ecosystem health background/pre-disturbance conditions are largely absent or not known. – For most major basin mainstems, general land use/ land cover data is available and NPSP 'potential' can be identified in a general sense. – Water quality objectives have been proposed for most mainstem rivers but not for tributaries or lakes. – Water quality for mainstem rivers is known but NPSP contributions are largely not partitioned to specific land use/management or background. – Tributary data are available for some mid-reaches but both pre-disturbance data and headwater data is lacking; tributary data for those feeding lakes is largely absent. – Data for aquatic health for tributaries, lakes, and mainstem rivers is poor, particularly for fish species.

Question 2: How much NPSP is within a given watershed?

Challenges	Observations
– Is there adequate flow and concentration data to answer this? – Can models be used effectively and validated? – Are export coefficients and event mean concentrations applicable for watershed in Alberta? – Do we have knowledge for different scales like the mainstem, tributaries, and edge-of-field, if applicable? What are the gaps?	– Quantification of NPSP loads from headwater tributaries to mainstems is poor or not comprehensive in most basins.Even when loads are calculated, determination of how much is NPSP and how much is 'natural' has not been done. – Models are beginning to be used but they are in their infancy and often the modeling approaches are different and sometimes can be applied incorrectly. A thorough scientific evaluation of the applicability and usefulness of export coefficients for Alberta watersheds has not been done. – Adequate flow and concentration data is lacking for headwater tributaries such that loads from each tributary to the mainstem are difficult to calculate. – The current monitoring system does not identify and quantify NPSP sufficiently. – Existing monitoring is focused on the mainstem or specific tributaries and therefore load estimations throughout the watersheds cannot be determined. – Often we do not understand the contributions of snow melt and rainfall on NPSP.

Question 3: What land cover and management practices are contributing to NPSP in the water body and/or watershed?	
Challenges – Are there general land use linkages that have been determined? – Are these applicable to the watershed as a whole? Where are the gaps? – Have land use/cover relationships been established? At what scale? For what land uses/covers? – Can we determine how much load is allocated to each land use/cover? – How much of the load can be considered natural? – What are the gaps in knowledge?	**Observations** – General land use linkages have been determined in the scientific literature. – Linkages for the headwaters area and public lands have not been validated for Alberta landscapes. – Loads or export coefficients for land use/cover types are available but are often not applicable for management decisions to be based upon. – The natural conditions can mask NPSP and are not quantified. – It is not clear how much load can be considered 'natural' because pristine watersheds that may help give an indication of background loads are largely lacking in data. – It is not clear how recreational activity in the headwaters is contributing to NPSP.

Question 4: What mitigation and management strategies are the most effective to reduce NPSP impacts and how cost effective are they?	
Challenges – Do the strategies need to target concentrations, loads and/or exports? – Do the strategies apply throughout the watershed, or only in critical source areas? – Have the strategies been scientifically verified to improve water quality? In what time frame? And, at what scale? – Are the social and economic benefits and constraints known? – Are the strategies integrated between sectors and have potential risks of unintended consequences been identified?	**Observations** – Linkages between specific land management activities and reductions of NPSP are not known although work is underway for some sectors. – The social and economic benefits and constraints of implementation have not been comprehensively studied for the Alberta geopolitical landscape.

5.2.2.2 A Strategy to Ensure Effective Management of NPSP in the Long Term

Looking at the scientific requirements identified above, it is evident that the current method for monitoring and assessment for NPSP needs to change; this includes assessing how the collection, sharing and analyzing of data is completed. The results of this change in monitoring and assessment will also inform the development and use of models in an adaptive management and cumulative effects approach. Such a change will also allow the effective quantification of NPSP in our watersheds and, if necessary, the implementation of science-based management actions to mitigate the impacts. Although point source pollution (PSP) was outside the scope of this project, any activities to monitor and reduce NPSP should be made in concert with activities to reduce PSP.

Several tools could be developed to assess NPSP and PSP and to holistically manage pollution, at a watershed or regional scale. Although these tools will take time and resources to develop, they are required to properly manage NPSP and to address the linkages between land cover, land use and water quality. To fully address the issue of NPSP, the following NPSP research areas should be developed:

- **Export coefficients and event mean concentrations:** The NPSP Research Partnership should review published export coefficients and event mean concentrations (EMCs) to identify data gaps and then develop and refine provincially-representative Alberta-based export coefficients and EMCs for NPSP. The development of the export coefficients and EMCs would help inform modeling and prioritize potential areas of concern provincially and, in particular, in the White (settled) Area.
- **Monitoring:** The NPSP Research Partnership should design a long-term water quality monitoring program in each of Alberta's eleven watersheds to quantify NPSP for major tributaries and the mainstem rivers as part of the existing Long Term River Network (LTRN) data currently being collected. This program development should be done in coordination with WPACs, ESRD modelers and limnologists, and the program design results should align with the newly established Integrated Monitoring, Evaluation and Reporting Framework (which is working to create a centralized knowledge-share system for monitoring led by the GoA). Priority basins in the next five years would be the Bow, Oldman, Battle and North Saskatchewan. The study design should suggest a full monitoring program, including location, frequency and parameters to be sampled with an emphasis on characterizing runoff event contributions (i.e., from snowmelt and rainfall).
- **Land data:** The NPSP Research Partnership should identify priority land use, land cover, and land management data required to develop linkages between land and water quality at multiple scales. Critical source areas should be defined, with particular emphasis given

first to these priorities areas for acquiring detailed data (e.g., LIDAR-Light Detection and Ranging, which provides a 3D profile of the ground).

- **Quantify cumulative reduction strategies:** The NPSP Research Partnership should identify research needs as they relate to BMP implementation and cumulative NPSP reduction. As many industries are beginning to document the effectiveness of their reduction strategies, synergy could be created by examining this effectiveness from a cumulative effects perspective. This could include a research program (possibly involving academia) that considers sub-watershed wide implementation of NPSP BMPs across all sectors and land users (e.g., in one watershed, BMPs could be implemented to address recreation, forestry, transportation, agriculture and urban NPSP).
- **Models:** The NPSP Research Partnership should, with those who currently apply models for water quality in Alberta, review landscape models that are or could be used to appropriately model NPSP in Alberta and provide recommendations to increase consistency, communication and integration across the province. This would include both mechanistic models and export coefficient-based models.
- **Data management and access:** The NPSP Research Partnership should provide guidance for how water quality and land use databases, including water quality data collected as part of *Water Act* approvals, should be stored, managed and made accessible to all stakeholders.

As more research improves understanding of NPSP, the lead, working with the research partnership, should channel this new knowledge to policy-makers, planners and implementers for better NPSP management.

5.2.2.3 Interim Research and Management Strategies

All of this work will take time. However, as the cumulative effects of potential NPSP in each basin build over time, the GoA should not wait for the science to catch up with reality. We need to take action to manage NPSP now. To build momentum and start managing NPSP today, several potential strategies that also work towards the goal of better water quality are described in Table 3.

These interim strategies alone will **not** address the core issues of NPSP; they must be implemented in conjunction with the long-term research strategy described above. They can, however, get NPSP moving forward and on the radar in the short-term.

Table 3. Potential Interim NPSP Strategies

Potential Interim NPSP Strategies	Lead
Pilot Program — Risk Analysis and Mapping for High Risk Areas in Various Watersheds Focus on each of the major watersheds, conduct one pilot for each. **1. Identify Risk** Using an expert, criteria or GIS-based approach, prepare a list of suspected NPSP hotspots and prioritize the list. This might include: – Outlining the contributing factors for NPSP to use as criteria for identifying higher risk areas (slope, drainage, land use in area, etc.). **2. On the ground Mapping** During or just after a storm event, initiate a group (maybe students?) to complete a synoptic survey. Set NPSP Outcomes: – If an NPSP issue is identified through the mapping exercise, work with local stakeholders to set outcomes in a plan and undertake actions to achieve outcomes (could be a stewardship lake group, agriculture area, etc.). **3. Pilot BMPs** GoA should work with the WPAC (or any watershed group could take the lead) and sectors to pilot different BMPs to mitigate contributing factors. All sectors in the watershed should be included; for example: **a. Examine the connection between agricultural BMP uptake and NPSP:** If not already done, conduct an assessment of agricultural BMPs to determine which are the most effective. Conduct an assessment of BMP uptake and barriers to implementing these BMPs. If the top barrier is economics, look at the work of Alternative Land Use Services and other ecological goods and services payment schemes and how this might work for NPSP issues. **b. Help Smaller Municipalities Manage NPSP:** As every municipality has different circumstances, needs and capacity related to NPSP management, the Province may need to help smaller municipalities take steps to improve stormwater management. More incentives for LID can be given to smaller municipalities.	GoA NPSP lead with sector support
Do an Economic Analysis There is an economic cost to decreased water quality in the province. We need to calculate this cost (i.e., show that as water degrades, the cost to seek good source waters, to treat, to distribute, etc. increases). A lack of good quality water supplies can also limit economic opportunities; we should quantify the economic losses arising from NPSP in Alberta. What are the costs and benefits of investments in NPSP mitigation?	GoA NPSP Lead
Undertake Concerted Lake Management Prepare a list of the top recreational lakes suspected of having NPSP issues and prioritize the list. Starting with the highest priority recreational lakes (determined by lake limnologists), conduct ground-truthing and if an NPSP issue is identified, work with local stakeholders to set outcomes, including a lake nutrient budget and undertake actions to achieve outcomes. – Develop a provincial lake management plan. – Hold a conference or produce a summary of "lessons learned" from the past 20 years of lake monitoring and lake research (e.g., Pine Lake restoration, Alberta Water Research Institute's Lake Nakamun experiments).	ALMS

Potential Interim NPSP Strategies	Lead
Mitigation Strategies with Water Features Promote integration of water and watershed management related strategies and their guidelines, policies and regulations to collectively manage NPSP more effectively. The management of wetlands, riparian systems, aquatic habitats and safe drinking water protection are all part of NPSP management, yet the implementation of these management strategies is still often done in isolation. A more holistic approach could be used to look at how landscape capacity can be maintained or restored to better manage NPSP. Some examples include: – Align policy and legislation, enforcement and compliance to support NPSP management. – Existing policy and planning tools should be assessed to ensure they are effective at managing NPSP. The cost effectiveness of management strategies should also be considered. – Conduct a study that links all AWC project recommendations concerning mitigation strategies (wetlands, riparian, etc.) for a coordinated and integrated watershed management approach supported by a focused funding or resource strategy.	GoA/AWC
Improve Education and Awareness Develop a NPSP website to share knowledge among experts, sectors and the public. – Expand public education program on controlling NPSP at the source. They may want to work with existing tools such as Alberta Watershed Toolkit www.sustainabilitycircle.ca/index.php/about-us/current-projects/watershed-toolkit	GoA NPSP Lead
Headwater Recreation Activity and Conservation Pilot Project Public Lands should work with the Recreation sector on headwaters recreation activity and conservation pilot projects for two locations: west of Edmonton and west of Calgary. The pilots could include the following areas of focus: – Education and awareness. – Municipal partnerships with public lands for the pilot. – Incentive programs for conservation. – Agreements to set aside specific recreational lands for off-highway all-terrain vehicle use.	Public Lands
Get Sectors Involved To provide their best advice to the NPSP Lead, sectors that contribute to NPSP need to be informed by science. In turn, they can help translate science to inform policy and decision-making. To do this, sectors need to have a comprehensive understanding of their contribution to NPSP loading in the watersheds in which they operate. Thus if they haven't already, these sectors should undertake an assessment of their NPSP knowledge and management and any barriers to change. Make the assessment available to the NPSP Lead and the multi-sector Implementation Advisory Partnership. This assessment will inform provincial level NPSP direction and should: – Identify what each sector is trying to achieve in NPSP management; – Identify sector knowledge gaps and research priorities; – Identify sector tools for management (regulatory and non-regulatory); and – Identify areas for sector improvement. The Recreation sector refers to motorized All-Terrain Vehicle use and random camping on public lands, particularly as it occurs in the province's headwaters (Crown lands). An assessment of this sector could be led by Public Lands Division (ESRD), in collaboration with its stakeholders. "Agriculture" includes all components: crop, livestock, etc. "Urban" includes large and small, urban and rural municipalities with a focus on stormwater management and source controls. Forestry includes the footprint from linear disturbance from logging, roads, prescribed burns, etc. Similarly, oil and gas includes the footprint from linear disturbance from roads, well sites, pipelines, decommissioning work, etc.	AWC to coordinate

6.0 Conclusion

NPSP is a complex and challenging issue in Alberta and requires a coordinated effort. Evidence shows that NPSP exists, but there is not a clear picture of the extent and the many factors that are contributing to the problem. Without this knowledge, it is challenging to know what is needed to manage this aspect of water quality.

However, our lack of knowledge should not be taken as a reason to delay action. Looking at what we know about NPSP in Alberta, as well as efforts in other jurisdictions, we can start to design a roadmap of where we need to go. Fortunately, many other water quality, land use and water management initiatives in the province (e.g., Cumulative Effects Management, regional and watershed planning, water quality management frameworks, monitoring and modeling initiatives) align well with NPSP work. Raising awareness that these initiatives should incorporate NPSP is an essential beginning.

And finally, no one agency or sector can manage NPSP. A framework for collaboration already exists in Alberta through the *Water for Life* strategy. Tapping into this framework — to engage governments, sectors, and watershed partnerships — will speed the development of an effective NPSP management framework for the province. This improved connectivity of policy and planning at multiple scales, along with the cumulative effects approach of monitoring and assessing progress, will lead to better decisions in the management of NPSP and ultimately, improved water quality in Alberta.

Glossary of Terms and Types of NPS Pollutants

Concentration	The mass of a parameter that is contained in water (e.g., mg of phosphorus per L of water).
Constituent	The substance or elements found in a water body.
Contaminant or Pollutant (synonymous)	A substance that makes something dirty or polluted or toxic, from natural or man-made sources but high enough concentrations to impair water quality for a particular use or to degrade aquatic ecosystem health.
Critical Source Area	A location where there is a high concentration of nutrients or pollutants and the risk of runoff is high.
Event Mean Concentration	A method for characterizing pollutant concentrations in receiving water from a runoff event often chosen for its practicality. The value is determined by combining (in proportion to flow rate) a set of samples, taken at various points in time during a runoff event, into a single sample for analysis.
Export	The mass of a parameter that leaves a land area (watershed or land type) through surface runoff in a given time (e.g., $kg/km^2/year$).
Export Coefficients	Represent the average total amount of pollutant loaded annually into a system from a defined area, and are reported as mass of pollutant per unit area per year (e.g., kg/ha/yr).
Pollutant Load (Load)	The total amount of a pollutant, or a group of pollutants, carried by a water body. (The total mass of a parameter that a stream carries past a given location in a given time; e.g.; kg per day).
Metals	Such as aluminum, copper, etc. occurring naturally in Alberta's water bodies but can also be released through land use activities such as mining or coal power generation. Accumulation can lead to a reduction in aquatic biodiversity and hinder crop growth.
Nutrients	Essential components of any aquatic ecosystem; however, an excess of phosphorus (and to a lesser extent nitrogen) can stimulate aquatic plant growth, leading to algal blooms and changes in the flora and fauna of a water body.
Organics	Organic carbon occurs naturally in aquatic ecosystems in Alberta but an excess of carbon can lead to decreased oxygen for other aquatic species.
Pathogens	Disease-causing organisms associated with the gastrointestinal tract of mammals that can affect human and animal health.
Pesticides	Synthetic substances introduced into the environment to control pests in agriculture, forestry and urban landscapes. Designed to adversely affect certain plants and animals; their presence in water bodies may pose risks to aquatic ecosystem health. Herbicides, in particular, may jeopardize our ability to grow crops. The impact of multiple pesticides on the environment is not clearly understood.

Pharmaceuticals	A wide range of synthetic chemicals used to treat, cure, maintain and/or enhance human and animal health and well-being. Pharmaceuticals as NPSP are a result of improper disposal of prescription drugs, untreated waste or overland flow from livestock operations and even plumes from residential septic systems. Researchers have demonstrated pharmaceutical exposure has led to the sexual disruption of fish, and kidney failure and death in some wildlife.
Salts / salinity	Natural waters contain a variety of salts including calcium, magnesium, potassium salts of bicarbonate or chloride, etc. However an imbalance can impair aquatic plants and animals, can stress sensitive aquatic communities, reduce species diversity and hinder crop production.
Total Suspended Solids (TSS)	A measure of the sediment and particles that are suspended in water, which can include silt, clay, organic matter and other particles. TSS is often a vehicle in which contaminants are transported. High TSS concentrations are known to affect fish and degrade aquatic environments.
Watershed	The area of land where surface water runoff from rain and melting snow or ice converges to a single point; can be delineated at multiple scales.

Appendix A: Team Members

Current Members	
Ron Axelson	Livestock/ Intensive Livestock Working Group
Yin Deong*	Large Urban/ City of Calgary
John Englert	Alberta Transportation
Andrea Kalischuk*	Alberta Agriculture and Rural Development
Bernd Manz	Small Urban/ Alberta Urban Municipalities Association
Sharon McKinnon	Cropping/ Crop Sector Working Group
Ron McMullin	Irrigation/ Alberta Irrigation Projects Association
Stephanie Neufeld*	Watershed Planning and Advisory Councils
Dwight Oliver	Rural/ Alberta Association of Municipal Districts and Counties
Lynn Robb	Fisheries Habitat Conservation/ Trout Unlimited Canada
Tracy Scott	Wetland Conservation/ Ducks Unlimited Canada
Jason Unger	Environmental/ Environmental Law Centre
Martin VanOlst	Environment Canada
Jay White*	Lake Habitat Conservation/ Alberta Lake Management Society

Alternates and Past Members	
Elaine Bellamy	Cropping/ Crop Sector Working Group
Laura Bowman	Environmental/ Environmental Law Centre
Rick Istead	Cropping/ Crop Sector Working Group
Roger Kelley	Fisheries Habitat Conservation/ Trout Unlimited Canada
John Kolk	Livestock/ Intensive Livestock Working Group
Nicole Rowney	Large Urban/ City of Calgary

**indicates the person was also a member of the technical team*

Project Managers: Meredith Walker, Alesha Hill and Petra Rowell

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Appendix B: Summary of Recommendations and Timelines

Recommendation	Timeline
Recommendation 1: Government of Alberta, with Alberta Environment and Sustainable Resource Development, within one year of the approval and release of this report, identify an internal Non-point Source Pollution lead that will coordinate and facilitate the development of a multi-stakeholder process to set the direction on how to better manage NPSP. *Key Outcomes:* – Identify an internal ESRD Lead – Coordinate a multi-stakeholder process that will bring together all key stakeholders	**1 year**
Recommendation 2: GoA, with ESRD as lead, through the multi-stakeholder process, coordinate and promote the development and implementation of a provincial strategic approach. This will set provincial level outcomes and priority research needs for NPSP management. The provincial strategic approach will also outline alignment with existing policy frameworks and the development of regional plans and associated management frameworks. This approach to NPSP will be completed within two years of the approval and release of this report. *Key Outcome:* – Provincial Strategic Approach	**2 years**
Recommendation 3: GoA, with ESRD as lead, within two years of the approval and release of this report, will coordinate a Multi-Sector Implementation Advisory Partnership that will recommend cost effective and practical solutions to address NPSP and support implementation. *Key Outcome:* – Coordinate a Multi-Sector Implementation Advisory Partnership	**2 years**
Recommendation 4: GoA, with ESRD as lead, within two years of the approval and release of this report, create and coordinate an NPSP Cumulative Effects Research Partnership to address the gaps in scientific knowledge of all aspects of NPSP in Alberta. *Key Outcome:* – Create an NPSP Cumulative Effects Research Partnership	**2 years**
Recommendation 5: GoA, with ESRD as lead, in collaboration with the NPSP Cumulative Effects Research Partnership, develop an NPSP research strategy within two years of the approval and release of this report, which will lead to better understanding and improved management of NPSP. *Key Outcome:* – Research Strategy	**2 years**

Appendix C: A Scientific Primer on Non-Point Source Pollution: Utilizing Agriculture to Tell the Story of Modeling Challenges for NPS Pollution

Provided by Stephanie Neufeld and Andrea Kalischuk, 2012

Purpose

A high level of technical expertise is required to work within the field of non-point source pollution (NPSP), which includes a working knowledge of hydrological processes, water quality and linkages between land-use and transport processes. The purpose of this document is to provide a general technical approach on how to assess NPSP and the information that is required. Examples from the agriculture sector are used to illustrate the NPSP complexity, given the multiple commodities and land-use practices. It is suggested that general model approaches to NPSP are misrepresenting the amount of NPSP that is exported from watersheds. Generalizations in large mechanistic models are inaccurate, particularly for complex hydrology such as occurs in the irrigated areas of the province. An on-the-ground, site-specific understanding of NPSP and the development of Alberta-specific export coefficients are required to alleviate current modeling limitations.

Introduction

It is well known that physical, chemical and biological characteristics and processes in a watershed affect the water quality of waterbodies that drain these areas. Changes to either the processes and/or physical characteristics of a watershed will ultimately lead to changes in water quality in downstream waterbodies. If these changes result in alteration of background water quality and/or quantity it can be considered pollution. And, without the ability to trace back to a single point of origin and/or discharge, it can be defined more specifically as NPSP.

NPSP occurs through many mechanisms and has many forms (physical, chemical, or biological). It can occur from the addition of chemicals to the land base (e.g., nutrients, pesticides) which then run off into waterbodies and increase background levels. It can also occur when watershed functions and processes are altered (e.g., removal of trees alters hydrology and results in erosion of naturally occurring sediment) which results in changes to downstream water quality through increased additions or changes in the in-stream physical environment. In many cases the alteration of the hydrological regime (the mechanism of which NPSP moves into surface water) and alteration to the land base (change in cover, or the addition of chemicals) acts synergistically to result in NPSP. Understanding these relationships at multiple scales (field level to watershed level) is key to effectively managing NPSP.

In general when assessing the extent and impact of NPSP for a given water body or watershed there are some basic questions that should be addressed.

- Is NPSP an issue for a given water body or watershed (i.e., what is the risk?)?
- How much NPSP is within a given watershed?
- What land uses (management practices) and land cover are contributing to NPSP in the water body?
- Given the impact on the water body, what mitigation strategies are the most effective to reduce NPSP impacts?

The answers to each of these questions are complex and depend on the existing body of knowledge around the water bodies and/or watersheds of concern, which varies geographically and depends on scale, as well as the overarching scientific knowledge base of land use linkages to water quality. In addressing the aforementioned questions there are some basic considerations that should also be addressed. In an Alberta context when we ask "what is the state of knowledge of NPSP and its management for each major basin" we are really asking the following:

Question	Considerations
Is NPSP an issue for each basin?	– Can we identify the water quality parameters of concern or that we would expect to be a problem given our knowledge of land-use? – Are background/pre-disturbance conditions known? – Are water quality objectives and/or guidelines relevant for the waterbodies in the basin? – Do we have water quality data? Are these limited to mainstem rivers? Tributaries? Lakes? – Has aquatic ecosystem health been affected by NPSP? Have health indicators been measured? Where?
How much NPSP is within a given watershed?	– Is there adequate flow and concentration data to answer this? – Can models be used effectively and validated? – Are export coefficients applicable for this watershed? – Do we have knowledge for different scales like the mainstem, tributaries, and edge-of-field, if applicable? What are the gaps?
What land cover and management practices are contributing to NPSP in the water body and/or watershed?	– Are there general land use linkages that have been determined? – Are these applicable to the watershed as a whole? Where are the gaps? – Have land use/cover relationships been established? At what scale? For what land uses/covers? – Can we determine how much load is allocated to each land use/cover? – How much of the load can be considered natural? – What are the gaps in knowledge?
What mitigation strategies are the most effective to reduce NPSP impacts?	– Do the strategies need to target concentrations, loads and/or exports? – Do the strategies apply throughout the watershed, or only in critical source areas? – Have the strategies been scientifically verified to improve water quality? In what time frame? And, at what scale? – Are the social and economic benefits and constraints known? – Are the strategies integrated between sectors and have potential risks of unintended consequences been identified?

What we know about NPSP: Landscape Linkages to Water Quality

The scientific community has worked hard to understand and quantify the linkages between watershed characteristics and water quality. This includes understanding the effect of changes in watershed characteristics at multiple scales (field scale to small and large watershed scale) on water quality. This section is intended to outline the current 'state of knowledge' on landscape level linkages to water quality in the scientific community.

There are many methods to linking water quality to watershed characteristics. From the landscape perspective, the validity of the methods depends on the scale (field level to large basin) and the detail of the land use/cover categories, which will affect the interpretation of the results. For example, land cover is often categorized into broad groupings such as agriculture, forest, wetland, urban land. In other studies linkages are made between different crop types (row crop, direct drill) and fertilizer applications.

Once landscape metrics are developed, there are various ways to link water quality characteristics with these landuse/cover types. Water quality is typically measured by quantifying either in stream concentrations or the load of given parameter, which is the concentration multiplied by the volume. Both of these water quality measurements are subject to monitoring bias and error. Water quality is highly variable through time and is affected by runoff conditions and in stream processes. Average concentrations can be biased by capturing or missing a high flow event when concentrations are typically much higher. These events may only occur infrequently but sampling may not account for them. Flow volumes typically have a measurement error of 5%, but could be much larger, particularly if a stage/discharge curve is not representative.

Water is often linked to the land via the calculation of an export coefficient, which is the load divided by the contribution area. Theoretically, the benefits of calculating exports are to allow comparison among watersheds with different landuses or for individual landuse types. In the following sections we will discuss the current knowledge around each of these methods to allow a better understanding on NPSP knowledge and management.

Literature reviews on concentrations, loads and exports

Drawing associations between water quality and watersheds with different landuses is often done to assess potential effects of landuse change on water quality. The most typical approach involves comparing water chemistry concentrations or loads among watersheds of different landuse/land cover types. Research of this type has been completed throughout the world with a focus on problem areas and landuses such as the Midwest USA where NPSP from agriculture has been recognized as a major threat to waterbodies, given the extent of its footprint.

For example, research has shown that agricultural watersheds have been shown to export up to three times more total phosphorus (TP) than forested watersheds and concentrations in agricultural streams are typically higher (Dillon and Kirchner 1974, Vaithiyanathan and Correll 1992, Cooke and Prepas 1998). Total nitrogen (TN) concentrations have also been shown to be elevated in streams and rivers that drain agricultural land compared to those from forested catchments (Omernik 1977, Keeney and DeLuca 1993, Jordan et al. 1997, Chambers et al. 2006) and concentrations increase with the proportion of crops that require fertilizer (Mitchell et al. 2009).

Export varies among catchment land use types (forested or agricultural) and temporally within the same catchment (Sharpley et al. 1994, Johnes 1996, Haygarth and Jarvis 1999). For example, Dillon (1991) found that in forested catchments in central Ontario, mean annual export of TP ranged from 1.8 to 25.5 kg km^{-2} yr^{-1} over 12 years and

Munn and Prepas (1986) found that forested catchments on the Boreal Plain of northern Alberta ranged in export from 7.5 to 13 kg km^{-2} yr^{-1} over 1 year. The same variability is found in agricultural catchments. Reed and Carpenter (2002) found that TP export varied from 18 to 69 kg km^{-2} yr^{-1} in six agricultural catchments in Wisconsin. On the Boreal Plain of Alberta, Cooke and Prepas (1998) found that high variability existed in TP export for agricultural (14 to 57 kg km^{-2} yr^{-1}) and forested catchments (13 to 22 kg km^{-2} yr^{-1}).

Further, the TP export from these catchments varied among years for all watersheds. This same pattern is found with nitrogen export as well. For example, nitrate loads from an agricultural watershed of the Minnesota River varied by an order of magnitude between years (Randall and Mulla 2001). Winter et al. (2002) found that TN export from mixed agricultural sub-catchments within the Lake Simcoe watershed ranged from 220 to 790 kg km^{-2} yr^{-1} while export from catchments with a high proportion of forest and scrubland ranged from 170 to 270 kg km^{-2} yr^{-1}. Factors contributing to variable nitrogen and phosphorus export from agricultural and forested catchments include year-to-year changes in climate (timing and amount of precipitation), natural hydrology, soil type, catchment slope, percent of the catchment as wetland, percent of the catchment as agriculture, and the intensity and type of agriculture within the watershed (Dillon and Kirchner 1974, Munn and Prepas 1986, Abrams and Jarrell 1995, Foy and Withers 1995, D'Arcy and Carignan 1997, Anderson et al. 1998a, Cooke and Prepas 1998, Haygarth and Jarvis 1999, Reed and Carpenter 2002, Winter et al. 2002, Whitson et al. 2004).

Alberta Agriculture monitored 23 watersheds with varying agricultural intensities for more than a decade and found that water quality tended to deteriorate as agricultural intensity increased on the landscape, with intensity being measured by the census data on sales of fertilizer and pesticides, and the amount of manure produced in the watershed (Palliser Environmental Services Ltd and Alberta Agriculture and Rural Development, 2008). However, in long-term comparisons of areas that were low, moderate or high agriculture intensity, provincial scale soil and surface water quality have remained constant with time. That is, in the ten years of monitoring nitrogen and phosphorus concentrations in surface water, the water quality in the agricultural watersheds generally did not show any significant change. At a small watershed scale, it was found that surface water quality guidelines for nutrients were commonly exceeded (Palliser Environmental Services Ltd and Alberta Agriculture and Rural Development, 2008) even in low agricultural intensity watersheds, where TP and TN guidelines were exceeded more than 40% and >15% of the time, respectively.

The Alberta study also provided total phosphorus and nitrogen export coefficients for the dry land watersheds (Lorenz et al., 2008). The study showed that for the 23 watersheds, eco-regional characteristics are the most important attribute in determining nutrient export from watersheds, certainly more so than agricultural intensity. The potential for runoff and the subsequent transport of nutrients from the land to surface water increases with increasing precipitation. Generally, the Boreal Eco region receives a greater amount of precipitation each year compared to the more southern Eco regions, and hence exports are higher in the Boreal than Parkland or Grassland watersheds.

The Complexity of an Irrigated Landscape and NPSP in Alberta

Alberta's 13 irrigation districts are located in the Bow and Oldman river basins. Source water for the districts is snowmelt from the Rocky Mountains in the mainstem rivers, which may be stored in reservoirs, prior to diversion. Districts taking water from the Bow are at times impacted by point plus non-point sources of pollutants,

particularly phosphorus and pesticides. Similarly, just as water quality tends to degrade as it moves downstream in the mainstem rivers, water quality also tends to degrade as it moves downstream in the irrigation distribution system. Degradation occurs as water moves downstream due to natural biological processes and can be augmented by land-use activities, including agricultural production. In the Western Irrigation District, storm water returns from the City of Calgary are a major source for pesticides NPSP (Little et al. 2010).

The risk of NPSP from irrigation agriculture is higher than the risk from dry land agriculture. The increased risk relates to source and transport and is two-fold: 1) irrigated agriculture is high intensity agriculture with many inputs and subsequent higher yielding production and 2) irrigating fields may increase runoff risk, depending on the irrigation management. Studies have shown that the risk of nitrate-leaching to groundwater may increase under irrigation (Olson et al., 2005; Olson et al., 2009).

The scientific approach to studying NPSP in the irrigated areas is often complicated by urban NPSP (storm water returns), particularly within the Bow River Basin. Also, exports cannot be calculated for irrigated watersheds as the complexity of water conveyance pipelines and canals makes it difficult to outline a contributing area.

Nonetheless, data has shown that irrigation return flows often have significantly higher concentrations of nutrients, salinity and pesticides than irrigation source waters (Little et al. 2010). And, studies have examined the impact of irrigation return flow streams on receiving streams or rivers and depending on the watershed, irrigation return flows might have negligible, detrimental or beneficial effects on receiving stream water quality (Charest et al., 2012). As irrigation efficiency and management improves and open canals are moved into pipelines, the hydrology changes and return flows decrease. Hence, generalizations cannot be made with regards to the expected impact of irrigation return flows on water quality.

Modeling Export Coefficients and Limitations for Alberta Watersheds

As discussed, not all agricultural land exports similar amounts of nutrients, however; export can depend on natural hydrology, soil type, catchment slope, percent of the catchment as wetland, percent of the catchment as agriculture, level of agricultural intensity, and local precipitation patterns within the watershed (Dillon and Kirchner 1974, Munn and Prepas 1986, Abrams and Jarrell 1995, Foy and Withers 1995, D'Arcy and Carignan 1997, Cooke and Prepas 1998a, Haygarth and Jarvis 1999, Reed and Carpenter 2002, Winter et al. 2002, Whitson et al. 2004). What this means from an Alberta context is that unless export coefficients are tested and developed for the unique combination of processes and land cover and management practices in our watersheds, they may misrepresent the amount of NPSP that is exported out of the watershed. As well, export coefficients are variable throughout a watershed. Headwater areas have different climate, topography, soil characteristics, etc. and a parcel of categorized agricultural land will not likely behave the same in this area as in lower parts of the watershed. It is imperative that we understand these relationships before large mechanistic models are used to predict loads.

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Appendix D: The State of NPSP Knowledge and Management: Summary of findings from Charette and Trites (2011)

Although it is known that NPSP is occurring, the extent and risk of NPSP in Alberta is unknown.

- Numerous studies demonstrate definite and measurable impacts from urbanization, forestry and agriculture on a small watershed (local) scale.
- NPSP has been documented to occur from many activities in Alberta, including agriculture, forestry, mining, recreation, and urban development. The main pathways of NPS pollutants in Alberta have been documented to be primarily surface runoff, and to a lesser extent atmospheric deposition, wind and groundwater.
- Although NPS loading to Alberta's mainstem rivers is occurring, its contribution in the mainstem rivers is unclear as the Alberta Provincial River Water Quality Index generally rates water quality as good in the major river basins of the province.
- It is expected that streams, tributaries, and lakes are most affected by, and are at most risk from NPSP, due to their relatively low dilutive capacity compared to larger mainstem rivers. However, monitoring data and tools for risk analyses (i.e., water quality objectives) are gaps that restrict current assessment. Impairment of water quality in these water bodies is of particular concerns for fisheries, as small streams and lakes often provide Alberta's primary fish habitat.
- There is a particular gap of knowledge about potential NPSP in the headwaters of Alberta's watersheds owing to lack of land use and water quality data.

Contributions of NPSP will vary across watersheds and within locations of a watershed, which makes it important to have a watershed specific understanding of NPSP.

- Variations in NPSP occur owing to Alberta's natural watershed variability in land surface forms (shape, size, slope of the earth's surface), soil textures and climate. The transport of NPSP is most common when surface runoff occurs, during snowmelt and rainfall.
- The water quality parameters of concern for NPSP will vary, depending on the disturbance activity. For example, the NPS pollutants associated with oil and gas will be different than those associated with municipal development.
- Generally, critical source areas or areas with high connectivity to water are the most likely to transport NPS pollutants to streams. Typically, critical source areas are the riparian areas and wetlands. Minimizing the extent and intensity of the human disturbance footprint within a watershed's sensitive areas will alleviate some of the risks associated with NPSP.

The cumulative effects of NPSP are not understood, as the current approach is on a sector basis. Additionally, the scientific knowledge of NPSP and solutions varies by sector, with some sectors further advanced than others.

- Some work on NPSP has been done within Alberta's agriculture, forestry, and municipal sectors although knowledge gaps still exist, particularly on the effectiveness of beneficial management practices.
  i. Agriculture Sector: The effects of agriculture are well studied in tributary streams, but impacts on mainstem rivers remains a gap. The risk of agricultural NPSP is greatest for those watersheds that have the greatest proportion of their basins as agricultural land and where agricultural development is intense, namely within the Oldman, Battle and Red Deer River basins. Nutrients, pesticides and pathogens are the main constituents of agricultural NPSP.
  ii. Forestry Sector: The impacts of forestry clearing activities are well studied in boreal Alberta (e.g. the Athabasca River Basin) and the impacts of wildfires are being studied in the Oldman River Basin. Linear disturbance from road construction poses the largest risk of NPSP associated with logging, although NPSP also increases with higher logging intensity (although variability can be large). The variability is related to hydrogeology and logging practices. Sediments and pesticides are the main constituents of forestry NPSP. Additionally, logging is a temporary impact (i.e., the forest grows back) as opposed to activities that result in more permanent changes to the landscape.
  iii. Municipal Sector: A good knowledge of impacts of large urban development (e.g. Calgary and Edmonton) on mainstem rivers is developing. Large urban developments in the Bow and North Saskatchewan River basins have a direct effect on main stem water quality, because the city's storm water directly discharges into the rivers. Small municipalities may also impact main stem rivers or tributaries. Sediments, metals, nutrients, salts, pesticides and pathogens are the main constituents of municipal NPSP. Chloride salt from road salt application and runoff is a good indicator of municipal NPSP.
- Less is conclusively known about NPSP within Alberta's oil and gas and recreation sectors.
  i. Mining, Oil and Gas Sector: The impact of coal mining in Alberta's eastern slopes is understood. And, the potential NPSP impacts of active oil sands mining has a fair amount of research but is currently a cause of debate. The potential NPSP from the non-direct disturbance of mining, like reclaimed sites and linear disturbance is not well understood. Sediments, hydrocarbons, metals (including selenium), and nitrogen (from explosives) are parameters of concern.
  ii. Recreation Sector: Very little is known about recreational (off highway vehicles, campers, and trail users) use impacts on water quality, however, from the few studies that exist, it is clear that a lack of recreational oversight or over-use in critical source areas can be damaging at a local level and can contribute significant loads of sediments to streams.
- NPSP has been studied on a sector-by-sector approach and hence, a large data gap exists in trying to understand the cumulative impact of NPSP across sectors within a watershed. This is of particular concern for areas in Alberta's watersheds where disturbances such as logging, ranching, oil and gas, and recreational uses occur concomitantly, like the headwaters.

Extensive gaps exist in monitoring, research and modeling, which are key tools to inform decision making for NPSP in Alberta.

- Monitoring gaps that should be addressed to better understand NPSP include:
  i. The establishment of a long-term water quality monitoring network for small watersheds and tributaries in the province.
  ii. Documentation on land use disturbances including the extent (location) and severity, particularly for the recreation sector which is expected to grow.
  iii. Cumulative effects of recreation, forestry and oil and gas activities in headwater areas.
  iv. Impact of agricultural activities on mainstem rivers.

  These data need to be centrally warehoused and publically accessible to best inform future decision making.
- Scientific research priorities for NPSP should be solution-oriented to assist in mitigating current impacts and to proactively plan for minimal impact in the future. Further work is needed on beneficial management practices to assess their effectiveness and also how long it takes after implementation for a measurable improvement in water quality. In some cases, site-specific water quality objectives need to be developed to provide an end-point goal.
- Modeling assists in decisions of what the future can look like, given different sets of scenarios. Currently, no model that is used in Alberta adequately addresses NPSP, owing generally to a lack of Alberta-validated export coefficients. This gap needs to be addressed to effectively utilize modeling tools.
- In all cases, the future work that occurs on NPSP should align with the provincial strategies on land and water planning as well as cumulative effects management. In most cases, NPSP will have to be considered along with point source management.

Appendix E: A Review of Policy, Practices and Regulation in Alberta and Elsewhere: Key observations from Sanderson and Griffiths (2012)

In Alberta, no single government department is responsible for NPSP management and there is no systematic approach for addressing the issues. Historically, NPSP effort in Alberta has focused on agriculture and forestry as these sectors cover the largest land base in the White and Green Areas, respectively. Focus has also been on municipal point and non-point discharges. Today, sectors use a variety of approaches that may include legislation, voluntary programs and incentives.

- Agriculture Sector: Education awareness and voluntary BMP adoption programs have been Alberta's main approach to dealing with NPSP in agriculture. A wide array of resources, programs and partnerships has been developed to support this approach. Key pieces of legislation relevant to managing NPSP from agriculture include the *Agricultural Operation Practices Act*, which describes requirements for manure management, and the *Environmental Protection and Enhancement Act*, which regulates activities associated with pesticides. Research continues on BMP evaluation by government and industry.
- Forestry Sector: The key policy tool for managing NPSP in forestry is the Timber Harvest Planning and Operation Ground Rules, which describe the requirements that licensees must meet as a condition of their harvest approval; these include mandatory requirements related to watershed protection and riparian lands, soils, habitat management and roads. The Government of Alberta monitors compliance through planned and random audits and field inspections.
- Urban Sector: In Calgary and Edmonton, the major components of NPSP management include a total loading management plan and a stormwater management strategy. Municipalities typically manage stormwater using regulatory and policy tools in the form of bylaws and formal plans, combined with a wide array of BMPs like those promoted by the Alberta Low Impact Development Alliance (ALIDA).[5] Erosion and sediment control guidelines are essential features of urban NPSP management.

Sanderson and Griffiths also looked at three Canadian provinces (British Columbia, Saskatchewan and Ontario). Similar to Alberta, none of the three Canadian provinces examined has a comprehensive integrated NPSP program but instead they take a variety of approaches:

- Ontario and Saskatchewan are devoting considerable efforts to source water protection strategies following serious outbreaks of waterborne disease in each province in 2000 and 2001, respectively.
- In British Columbia, the *Forest and Range Practices Act* governs activities of forest and range licenses and enables penalties for activities that damage sensitive sites, like off-roading in riparian areas. This Act is supported by a monitoring program.
- Ontario's 36 Conservation Authorities play a key role in watershed management, oversee many NPSP initiatives in their regions, and have been involved in preparing watershed assessments and source protection plans. Ontario's *Nutrient Management Act* regulates nutrient land application standards and practices. A 2009

5 For more on the Alberta Low Impact Development Alliance, see http://alidp.org/.

ban on the cosmetic use of pesticides appears to have significantly reduced concentrations of three commonly used pesticides in streams.

- Saskatchewan's Long-Term Safe Drinking Water Strategy is the focal point of that province's water management. The Saskatchewan Watershed Authority, a Crown Cooperation, has a wide mandate for managing and protecting water, watersheds and related land resources. Like Alberta, Saskatchewan uses BMPs extensively to manage NPSP from agriculture. The province is adopting a new legal framework for environmental management, including an Environmental Code that will define outcomes and require the regulated community to decide how it will achieve compliance.

While the United States and some European Union (EU) countries have legislative NPSP frameworks, no approach has yet been measurably successful in reducing NPSP loading to water bodies. In the United States, the federal *Clean Water Act* is implemented through the Environmental Protection Agency (EPA). The EPA's Nonpoint Source Control Branch requires each state to comply and report on its NPSP program, including water quality monitoring. Each state must also have a water management plan to address NPSP and limit discharges to meet those standards. Individual states may also have their own legislation and NPSP initiatives.The EPA produces manuals setting out BMPs to reduce NPSP from agriculture, forestry and the built environment, as well as a toolkit on water quality trading. The U.S. Department of Agriculture encourages BMPs through its Clean Water Program and provides some funding, but programs are voluntary.

The EU's Water Framework Directive requires each member country to adopt measures to reduce NPSP, including river basin management plans. The Nitrates Directive applies specifically to agricultural sources and requires mandatory measures to reduce nitrogen applications to the soil in vulnerable areas. The consultant report also looked at England, Scotland and The Netherlands.

- In England, the Environmental Agency is responsible for NPSP management and works with other departments (Agriculture and Natural England). As throughout the EU, famers must keep their land in good agricultural and economic condition if they wish to receive funding under the EU Single Payments Scheme. The National Auditor has been highly critical of the Environmental Agency's efforts to address NPSP.
- Scotland may be 10 years ahead of England in addressing NPSP though its Environmental Protection Agency. A 2005 General Binding Rule was introduced to limit diffuse pollution, which requires compliance with certain practices, but does not require special authorization. Sustainable Urban Drainage Systems, which is the implementation of Low Impact Development, are required on almost all new developments. The Scottish EPA trains rural agencies to raise awareness and undertake compliance monitoring.
- The Netherlands has very stringent rules for managing manure, fertilizers and other types of NPSP. There is a comprehensive water quality monitoring program and data is used to update plans to reduce nutrient runoff. The government funds research into ways to reduce nutrient loads from agriculture, especially for areas that have nutrient-rich soils. Even though the Dutch have a long tradition of being regulated, some farmers find the rules complex and onerous.

Finally, Sanderson and Griffiths draw on the experience of these other jurisdictions to outline the key components of an effective NPSP program and identify ways in which Alberta might develop a more comprehensive NPSP management framework of its own. Currently, in Alberta, several of these components exist to some degree. However, no comprehensive framework or coordinated approach to NPSP currently exists in the province. In fact, these components often occur in "silos" with responsibility for their implementation spread across several authorities.

Mitigation and planning around NPSP in Alberta should take a watershed approach and consider future growth in the province. As Alberta's population continues to grow, and land cover and use change, the extent and risk of NPSP changes, potentially including the water quality parameters of concern, as well as the location and extent of pollution. Hence, an NPSP plan must be current and flexible. Also, the implementation of best standards and management practices are best considered during land use planning for growth and intensification. It has been shown that NPSP prevention is more cost-effective and timely than remediation. Whatever the approach, it is critical that solutions are made-in-Alberta, given the unique landscape and culture of the people and sectors.

Appendix F: Looking at Potential NPSP in Alberta's Major Watersheds[6]

Hay River Basin

This basin, located in the far northwest of the province in the Boreal region, has a very sparse population with the main activity centered on an aging conventional oil and gas field. Some forestry and recreational activities also occur here. Linear disturbance from the oil and gas footprint, forestry roads and other disturbances may contribute to some TSS or other contaminant issues. However, the Hay River watershed is not monitored under the Long Term River Network thus NPSP and any contributions by sector are unknown at this time. Additionally, given its sparse population and remoteness, this basin is likely not a high priority for further analysis of NPSP at this time.

Peace/Slave Basin

The Peace/Slave basin is largely forested with the exception of the agricultural belt that follows the Peace River from the BC border up through Ft. Vermilion. The Peace River mainstem has been rated as good by Alberta's Long Term River Network and in general, does not have any major NPS contaminants of concern. This river is also rated by BC using the Canadian Water Quality Index, and has been given "fair" and "poor" ratings over the past several decades. Poor ratings are generally a result of colour and total suspended solids/sediment in years of high flows during the spring freshet. Nutrients and metals occasionally exceed guidelines in some sub-basins, but this again is related to seasonal discharge patterns.

Population is sparse other than at the two urban centres of Grande Prairie and Peace River. As well as forestry and agriculture, this basin has a large conventional oil and gas industry. NPSP from these activities might include increased sediment/run-off from land clearing, animal and plant wastes, fertilizers and pesticides. In-situ oil sands also occur in this basin. NPSP from this activity might include sediment/erosion, spills or contamination during oilfield saltwater injection or other disposal wells. Cumulative linear disturbance/footprint from the above activities may contribute to TDS loading. Peace River tributaries have had point source contaminant issues in the past, particularly the Wapiti River with its associated pulp mill activity. However, today, these activities are highly regulated and monitored. Emerging NPSP tributary issues may include the release of selenium and other associated metals in the upper Smoky/Wapiti watersheds where coal mining activities with its associated land disturbance and potential for increased run-off are increasing.

Because of its sparse population, this basin may not be ranked a high priority at the watershed scale, but local conditions and land uses could pose NPSP problems. However, given that economic activity is increasing, a further look may be warranted. Such work could be done to support the Land Use Framework regional planning processes for the Upper and Lower Peace regions.

Athabasca Basin (includes the Lesser Slave sub-basin)

This basin is largely forested. Logging has shown a minor, short-lived impact on water yield and nutrients. Agriculture, with its associated use of pesticides, is also present in the southern portion of the basin. Mining occurs in both the upper and lower part of the watershed with some selenium issues downstream of coal-mining activities. Forestry and oil and gas cumulative disturbance could potentially contribute to increased TDS loading. Coal mining and oilsands mining could potentially release more metals and other naturally-occurring constituents.

6 For a more detailed look at NPSP in Alberta's watersheds, see the basin descriptions in: CPP Environmental Corp. 2011. Current state of non-point source pollution: Knowledge, data, and tools. Report prepared by T. Charette and M. Trites for the Alberta Water Council. 154 pp.

The major source of data for the Athabasca River mainstem is the Long Term River Network. The Athabasca mainstem has been rated as good. Like other northern rivers, water quality in the Athabasca largely reflects seasonal flow patterns, which affects TSS and the constituents associated with them (nutrients, metals). A sub-basin of the Athabasca, the Lesser Slave is unique in that engineering works in the western tributaries in the 1960s contributed to increased erosion and sedimentation that still affects Lesser Slave Lake today.

There are several research and monitoring initiatives in place in the oilsands region to assess the impacts of this activity on water quality. NPS contributions on the Athabasca River mainstem are not well understood and there is little data on tributaries to support NPS pollution assessments. There is also little date on recreation, cumulative linear disturbance and urban run-off.

Given the level of economic activity in this basin, and the increasing international scrutiny, more work on understanding water quality is likely to occur in the near future. The degree to which NPSP is included in this future work is yet to be determined.

Beaver Basin

This basin has a mix of forested and agricultural lands. The relatively pristine Sand River provides about 50% of the flows to the Beaver River, which is a transboundary river where water quality must meet specific standards identified by the Prairie Provinces Water Board. Exceedances are few and flows are buffered to any NPSP sources.

An increase in land disturbed for agriculture could affect NPS loading in the future. A strong relationship between watershed disturbance and nutrient concentrations was demonstrated for 14 lakes in the Basin. Also, recent sampling of streams in the Moose Lake watershed demonstrated agricultural and urban NPS nutrient pollution. Lastly, an important increase in dissolved phosphorus since the mid-1980s in the Upper Beaver River was suggested to be caused by an increase in land disturbance and fertilizer application. Thus, similar to other basins, NPSP is being detected at the stream-scale. The Beaver River Watershed Alliance is currently developing a Biotic Fish Index and rapid assessment tool that will assess aquatic health and attempt to link land uses to areas showing stress. They are also about to complete a state of the watershed assessment. This document will identify any point and non-point issues and will guide priorities for future work in this basin.

North Saskatchewan Basin (includes the Battle sub-basin)

In the North Saskatchewan River (NSR) basin, land use and cover in the upper tributaries is largely forested and less disturbed (through recreational non-point source pollution is a concern). In the mid-reach areas upstream of Edmonton, agricultural land use (mostly cow-calf operations and pasture) is predominant, before urban land use begins to dominate with the City of Edmonton and surrounding communities. The landscape changes back to agriculture, though runoff from this area is low. Data have not been collected in a coordinated fashion that would answer definitively how much of a certain parameter (example TP at the SK-AB border) is attributable to an upstream tributary. Thus, it is not possible to divide the basin into its major tributaries (in terms of flow) and sufficiently calculate how much of the river's annual NPS load comes from each tributary. Some general points about NPSP loading in the NSR basin include:

- Streams with agriculture as the primary land use in the mid-reaches of the basin contribute a high overall percentage of protozoa to the NSR, though they are not the only source, despite accounting for a small percentage of the total flow above Edmonton. Streams with higher flow in the headwaters were not a significant source due to very low concentrations overall.
- TSS loads in the mainstem have been quantified using intake data at Rocky Mountain House (RMH) and Edmonton. It is estimated that of the total TSS load at Edmonton, around 45% is derived from upstream of RMH. About 65-67% of sediment load occurs in June and 18-19% occurs in July at both RMH and Edmonton. Within Edmonton, it is estimated that TSS loads are about 28,900 kg/day with 80% of that originating from storm sewers. This has been estimated to be less than 1% of the total TSS load for the river (Kessler). Other calculations put it closer to 3% (EPCOR). The sources of

sediment have not been quantified though mid-streams reaches could contribute a significant load of sediment to the river. However, loads may also be attributable to in stream erosional processes.

- Colour and TOC concentrations in the mainstem are associated with mid-reach streams where agricultural land use is predominant. However, this NPSP is limited to runoff periods, particularly spring runoff.
- Nutrient loads have not been quantified by sub-basin or tributary, though values are associated with high flow periods. Concentrations increase in a downstream direction and downstream of Edmonton. Loads within the City of Edmonton indicate that SSOs and tributaries contribute about 30% of the TP within the city annually with the majority from SSOs. A similar pattern was shown with ammonia where tributaries and SSO made up about 25% of the total load. Again, it is not clear how much of the total NSR load the urban footprint (SSO or tributaries) contributes.

From a concentration perspective, tributaries in the mid-lower reaches of the NSR show higher concentrations of nutrients, sediment, colour and pathogens in comparisons to the mainstem and headwater tributaries. As well, pesticide detections in these streams are more frequent than headwater (Cline, Ram, and Clearwater) or forested watersheds (Baptiste, Brazeau, Nordegg).In some mid-reach agricultural streams and urban streams concentrations of pathogens were consistently over agricultural and recreational water quality guidelines. Similarly, concentrations of nutrients are relatively low in the headwater tributaries (below ASWQ guidelines where applicable) whereas concentrations in mid-reach tributaries are notably higher (average concentrations 3 to 8 times higher). Clearly, these streams are affected by NPSP contamination; however determining sources and effects (mainstem and in-stream) remains a challenge as we do not have a reference condition.

Work has been done on calculating loads for some tributaries in the NSR and for storm water outfalls in the City of Edmonton. There are many well studied streams in the mid-reach of the NSR upstream of Edmonton, where the loads of key water quality parameters have been quantified and, in some cases, associated to land use. The City of Edmonton has done an excellent job quantifying loads from its storm sewer outfalls (SSOs). Alberta Environment and Water and Environment Canada have long-term monitoring stations at Whirlpool Point (headwaters), Rocky Mountain House, Devon, Pakan and at the Alberta-Saskatchewan border where monthly data could be used to estimate loads in the NSR.

Water utilities monitor daily raw water intake quality, though the suite of parameters is dependent on the facility. Other monitoring programs either through partnerships, individual efforts, or through AEW have also occurred. Modeling efforts on the NSR have been initiated but are largely limited to estimating total loads in the mainstem and comparing among reaches. All the aforementioned efforts allow for estimation of loads to or in the mainstem of the NSR. However, some critical gaps remain. One, most flow (>85%) of the NSR occurs in the headwater regions (upstream of Rocky Mountain House) and very little water quality data has collected for these areas. This, combined with the unique hydrology, water quality and land use in these areas that limit the ability to use surrogate streams in the basin as models, makes total load calculation and estimation unworkable for most parameters. Two, the movement of NPS parameters of concern are closely linked to runoff and in stream flow and as such most of the loading occurs during critical time periods. The historical sampling regime does not consistently capture these critical loading periods and, even when modeling techniques are applied; do not allow us to answer how much, when, and where when it comes to loading of a particular non-point source contaminant of concern.

The Battle River is a sub-basin of the North Saskatchewan although it joins this river downstream of the Alberta-Saskatchewan border. Water quality in the Battle River is generally rated as "poor" due to nutrients and pesticides coming from both urban and agricultural NPS sources. If further work were to be done to model NPS in a basin, this would be a good candidate for such work.

South Saskatchewan Major Basin

Within the South Saskatchewan basin, a great deal of work has been done on several pollutants of concern. For example, in the Bow sub-basin, phosphorus is an issue. Phosphorus comes from many sources in this basin including treated municipal waste water, stormwater, irrigation return flows, and as natural-occurring from tributaries above Calgary. Although percentages vary, urban run-off from the City of Calgary contributes nutrients, TSS and pesticides to the river. Tributaries to the Bow are impacted by both urban and agricultural run-off. However, based on work by AESRD, less than half of the phosphorus loading in the Bow River is generated by NPSP. AESRD is currently working with a partnership to develop a phosphorus management plan for the Bow River.

The Oldman River main stem has been rated as fair by the AENV Long Term River Monitoring Network. However, sub-basin ratings decline from west to east. Nutrients, fecal coliforms, suspended solids, pesticides, and pharmaceuticals have been identified as contaminants of concern on the major tributaries within the Oldman Basin, and in the City of Lethbridge storm drains. In the Oldman sub-basin, Pine Coulee Reservoir has been identified as a source of nutrients, but other reservoirs in the Oldman Basin could also be potential sources of nutrients, bacteria, and other contaminants.

Water quality of the South Saskatchewan River, downstream of the confluence of the Bow and the Oldman, is largely determined by the water quality of the inflowing Bow and Oldman rivers. The Red Deer River watershed is similar to the Oldman in that issues vary between one sub-basin to the next.

The South Saskatchewan sub-basin is about 80% agricultural lands, and is home to the majority of Alberta's population. The water supply in the Oldman and Bow basins is altered from natural flow conditions by reservoirs and an irrigation distribution system. Typically, water quality in the South Saskatchewan sub-basin is poorest when surface runoff occurs during the spring and early summer. During these times, there are increases total suspended solids and turbidity, along with other water quality issues associated with those particles.

For management purposes, the South Saskatchewan Major Basin has been broken into its sub-basins and a Watershed Planning and Advisory Council has been developed for each sub-basins. As these Council's undertake successive state of the watershed assessments, more focus may eventually turn to NPS pollution. Increased monitoring of reservoirs throughout the watershed would be beneficial, especially considering many reservoirs are sources of drinking water, water for food production, and for recreational activities.

Milk Basin

This basin is located in the extreme south of Alberta and is mainly prairie. Generally, water quality on the mainstem is rated "excellent" in the upper reach and "good" in the mid and lower reaches of the Milk River mainstem (as calculated using the Alberta Water Quality Index and reported in the MRWCC 2008 State of the Watershed Report). Water quality ranges from good, to fair to poor for various tributaries. Tributaries are generally ephemeral and tend to flow from spring thaw to July in a typical year. Generally, nutrients and fecal coliform bacteria are the main concerns on these tributaries, as well as high salt concentrations from springs and seeps that contribute flow to these waterbodies. The St. Mary River diversion creates a unique situation that increases phosphorus and sediment during the diversion period (approximately April to October). During natural flow conditions, salt and nitrogen tend to increase. Pesticides, monitored at the provincial LTRN site, are not an issue on the mainstem of the Milk River. A water quality report summarizing six years of data collected on the Milk River mainstem and on select tributaries will be available in March 2012.

Table: Water Quality Summaries by Basin

Source: State of the Watershed Reports by Basin

SOW Year	Scale	Changes in water quality	Degree of change	Direction	Causes/ Notes
Basin: North Saskatchewan					
2005	LTRN	Yes	Good-Poor	Good at headwaters; Fair central area; Poor more frequent after Edmonton	Point and Non point; health declined most significantly with increasing human and livestock density
Basin: South Saskatchewan					
2009	LTRN?	Yes	Generally good (no specifics on category changes)	Declines shown in channels carrying irrigation return flows, and downstream of Saskatoon	Flow declines caused by upstream management and diversion combined with land use practices have the most substantial influence on water quality
Basin: Bow					
2005	LTRN	Yes	Natural-Good-Fair cautionary	Further Upstream more consistent quality, most pronounced changes occurring downstream of Calgary	Natural and non-natural causes; Sediment, minerals, nutrients and organic material in water increased west to east; increasing deposits of treated wastewater effluent, storm water, agricultural runoff, and human and industrial activities
Basin: Red Deer					
2009	LTRN	Yes	Risk Indicator: 4 with low risk in upper reaches, 11 medium risk middle to lower reaches. Condition/ Overall Rating: varied locations within the watershed (see note)	Generally decline upstream to downstream on the main branch. Assessment of entire watershed varied based on Land use (see note)	Low DO always a concern (lowest in lower reaches); Low risk sub basins characterized by lower population density, accessibility, anthropogenic disturbances than middle and lower reaches; "The main characters contributing to a subwatershed's poor rating were linear development densities, resource exploration and extraction activities, nutrient concentrations in surface waters and land conversion activities"
Basin: Peace					
No SOW-assess-ment of ecosystem health completed in 2012	LTRN?	Yes	Good-Poor	Mainstream: generally good quality water; medium to small tributaries: generally poor	Nutrient enrichment due to cumulative point-source discharges in the agricultural lower Wapiti River; the smaller tributaries are most exposed and likely susceptible to the cumulative effects of land use and population patterns, in particular in the White Zone (Smoky/Wapiti, Upper and Central Peace sub-basins, and to some extent the western Wabasca sub-basin) — non-point source pollution

SOW Year	Scale	Changes in water quality	Degree of change	Direction	Causes/ Notes
Basin: Oldman					
2010	?	Yes	Good-Poor	Decreases downstream	Point and non-point sources; Most concerning attributes: land cover, riparian health, land use, water allocations, surface water nutrient levels
Basin: Sturgeon					
2012	No LTRN data avail.	No definite correlation	—	—	Graphs and images show a subtle increase in nutrient concentrations and reductions in land cover; Nutrient and coliforms spike near St. Albert (highest pop density)
Basin: Milk					
2008	?	Yes	Excellent-Poor	Main stream: excellent to good moving downstream Tributaries vary more: good to poor	Point and non-point, as well as more natural causes (bank erosion tied to "internal" phosphorus loading); water quality strongly tied to quantity (factor of management and climate); Lower water quality index scores are mainly attributed to fecal coliform, E.coli bacteria and phosphorus
Basin: Athabasca					
2008	?	Yes	Qualitative Impact Rating: Low/Moderate to Moderate/ high as you move downstream on the main branch	Headwaters: Athabasca Falls to Sinaning River Upper Athabasca: Hinton to Ft. McMurray Lower Athabasca: Ft. McMurray to Delta	Point source: pulp and paper, municipal discharge, oil sands; non-point source: forestry and agriculture, oil sands Low winter flows a concern

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